SCIENTIFIC AMERICAN

SUPPLEMENT, No. 1037

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Scientific American Supplement, Vol. XL. No. 1037. | NEW YORK. NOVEMBER 16, 1895. | Scientific American Supplement. $5 a year.
Scientific American, established 1845. | Scientific American and Supplement. $7 a year.

THE QUEEN OF MADAGASCAR

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ACCORDING to official dispatches dated at Andriba, October 9, the occupation of Tananarive was effected September 30, and the conclusion of a peace was arranged for subject to the ratification of the government of the republic. General Metzinger was named governor of Tananarive. Her Majesty Ranavalo Manjaka III is thirty-seven years old and has reigned since Nov. 22, 1883. Before this time she lived almost in misery, and one of her uncles was a common butcher of Tananarive. She is a little above the ordinary height and has delicate features, her complexion is a little darker than that of most of her subjects. She appears quite timid and she presides well at the solemn functions of her court. Among her relations her aunt, the Princess Ramasindrazana, is perhaps the most intelligent and exerts a considerable influence in political affairs. The Queen's eldest sister, the Princess Rasendranoro, thinks more of amusements than the affairs of state. The children of the Queen, Prince Rakatomena, twenty years old, and the Princess Razafinandriamanitra, take after their mother.

In the grand state ceremonies the Queen appears with a rich diadem on her forehead and is dressed in rich Parisian gowns. The dress which she ordered last from Paris is of silk embroidered with gold and trimmed with ermine, and bears the initials "R. M." Before 1886 the Hovas obtained most of their garments from London; since 1886 the greater part of them have come from Paris. When the Queen goes out on state occasions she is seated in a kind of gilded palanquin, a present from the Emperor Napoleon III, a large red parasol is held over her and she is surrounded by a brilliant assembly composed of a company of the guard dressed and armed like Europeans, a band of musicians and a group of body guards dressed in the old costume, the ladies of honor, the prince and princesses, and immediately preceding the royal palanquin walks the prime minister. Ranavalo III passes much of her time in kite flying and in playing lotto with her aunt, her elder sister, or the ladies of her court. The habits of the court are very much the same as those of Europe. Since 1869 the rulers of Madagascar have been Protestants and the Queen is the head of this religion in the island. For our engravings and the foregoing particulars we are indebted to L'Illustration.

THE HUMAN RACES OF MADAGASCAR.*

By E. T. HAMY.

ANTHROPOLOGY is undoubtedly that one of the natural sciences that has most to gain through the progress of distant voyages, and yet it is almost constantly the last to turn to a useful account the more or less fortunate tentatives of our explorers. This is because anthropological observation in barbarous or savage countries is beset with very peculiar difficulties, and because the collection of the materials for study that should render the examination of living man complete is often dangerous and always delicate. A traveler adequately prepared will indeed be able to bring home without much trouble a voluminous herbarium, prepare skins of animals and collect rocks or fossils, but he will in most cases deliver to us on his return only a few isolated anthropological specimens, discovered by accident, and some very vague notes upon the races among which he has lived for many weeks. It is therefore very slowly, specimen by specimen, and leaf by leaf, that are formed the special collections and the books that are indispensable for the advancement of our studies. And when peculiar circumstances occur, such as those that have given rise to our present exposition and the lectures that are the commentary of it, the professor whose duty it is to group the data designed to make well known a great country that our travelers penetrated two and a half centuries ago, for the first time finds himself face to face with an almost irrealizable programme.

The anthropology of Madagascar is, in fact, still full of gaps and obscurities. The maps that have been made of this country, which is larger than France, bear indeed the nomenclature of peoples in quite a large number, but more than half of these tribes are known to us only by name. The others are represented in our glass cases by a very small number of anatomical specimens, and their place has remained void in our note books of observations. If we add that Madagascar is a country almost without a history and without archæology, and that consequently the ties that connect the successive populations of this great land with each other are rather loose and fragile, we shall have justified the insufficiency of the sketch that we are going to present and which can be but a rough study, with a few broad, pretty well defined lines, upon a ground with undecided contours, certain parts, however, remaining entirely blank upon the canvas.

We as yet know so little as to the inhabitants of Madagascar that the total population of the island varies from triple to double in the estimation of our modern travelers.

In the eighteenth century, Flacourt and Montdevergue estimated the number of the aborigines at from 800 to 1,600,000, and in 1730 Grossin raised this figure to 2,000,000. All the moderns consider this estimate as still very insufficient. But, while Mr. James Sibree proposes the number of 4,500,000 to replace that of Grossin, Mr. Grandidier wavers between 4,000,000 and 5,000,000, Mr. Oliver ascends to 5,300,000, and Mr. Catat to 7,500,000.

As the island measures 1,515 kilometers from north to south and 470 kilometers in mean width, which gives it an area of 590,000 square kilometers (62,000 more than France), we find that the density of the population varies, according to the estimates of the above mentioned authors, between seven and thirteen individuals to the square kilometer. This low figure is due especially to the vast solitudes that are met with, especially between the coast zone and the region of the high plains. This latter has a much denser population. It occupies a relatively limited portion of the total superficies of the island, but is nevertheless inhabited by 2,000,000 individuals. There are certain portions of these territories of Imerina or Ankova whose population reaches nearly the mean figure of France. The Antisaika of the east coast offer also a dense population, which Mr. Catat estimates at sixty individuals to the square kilometer.

This entire population presents itself under traits that are profoundly different to the observer, who finds himself at first sight in real embarrassment. The individual called by the vague term of Malgash is not a negro. His facial morphology is entirely different from that of the Africans and recalls that of the Malays. Neither is he yellow. His hair is entangled in flocculent locks. He is a singular compound into which enter very different elements, some of which make us think at once of the Great Archipelago of Asia. At Bourbon and Mauritius . . . we meet with many of these Malgashes engaged as free laborers, and it requires nothing less than the combined use of all the varied resources that anthropology has at its disposal to solve all the difficulties to which the examination of these very composite subjects gives rise.

How does a people that only the 400 kilometers of the Mozambique Channel separate from the African continent thus exhibit itself profoundly mixed with ethnic elements borrowed from much more distant lands? A brilliant lecture that you have recently heard has already suggested to you an answer to this difficult question. You will remember the very precise conclusions drawn by Mr. Milne-Edwards from a general comparison of the African and Malgash faunas, and the very complete demonstration that resulted from the parallel thus established between the two zoological populations. Madagascar owes almost nothing to Africa, said our learned colleague. The animals that it nourished at a recent geological epoch were not African animals any more than those of to-day. These animals were of larger size, and the number of their species was greater. The country that they inhabited was therefore much vaster. It is a law of zoological geography that suffers no exception. There is always a rigorous proportion between the extent of a country and the size and the number of species that people it.

As the relations of Madagascar with the African world are almost null, it is therefore toward the east, and not toward the west, that must have emerged the terrestrial surfaces necessary to the development of species that have now disappeared. It is in the direction of the Indies and of the Sunda Isles that certainly lay all this insular and peninsular world, which must necessarily have had relations of contact with the great Malaisian islands from which it has been able to take its human population at the same time as its principal animals.

The incisions upon the bones of the fossil dinornis and hippopotamuses that Mr. Milne-Edwards has described to us, and to which I shall not revert, show without any doubt that man made at that time a part of the Malgash fauna. We do not know what this man could have been, and we shall not know until fortunate excavations shall have revealed to us his bones and primitive instruments. We are nevertheless authorized at present to suppose that this laborer of the first hour must have been like some one of those types of archaic humanity recognized in the state of survival upon the territories with which Madagascar thus shows itself to have been connected in prehistoric times and which are remarkable (Veddah of Ceylon and Negritos of the Philippines) by their very small stature and dark color.

Let us hasten to remark that no positive fact manifests the intervention of either of these very special prehistoric elements in Madecasse ethnography. Up to the present, no discovery has been made that puts us in the presence of skeletons or of living subjects that exhibit the features of the Veddahs or of the Negritos del Monte.

The legend of the Kimos alone calls up the remembrance of an ancient race whose small stature permits of comparing it with the Negritos, in a certain measure. These "Laplanders of the Negritos" (as Modave called them toward 1770), who were squat, stout and short, were three and a half feet in height. They lived in a great valley surrounded by mountains toward the center of the island, in about 22°. Modave spoke of these curious dwarfs only from hearsay. Commerson believed that he saw a specimen of them in a little woman of thirty years, who was 3 ft. 7 in. in height: but his description, which is very often cited, applies to no well fixed type, and, with its contradictions and its incoherences, renders it very probable that the great naturalist met with a pathological subject.

All modern travelers put themselves on record as regarding the legend of the Kimos false. Mr. Catat in particular, who traversed the south of the island of the country of the Betsileos at Fort Dauphin, found nothing there that recalled these "semi-men," who were nevertheless localized by Commerson quite near this latter establishment.

He chanced to be in the region where one claimed to fix the site of the battle in which the Kimos were exterminated of old, but did not see the hillocks in the form of tombs where these dwarfs slept their last sleep. On the contrary, he brought from this country of Amboulasa the curious photographs that I exhibit to you, and which show alignments of raised stones and of carved planks which are the work of an entirely different people, the Anatosy.

In default of the Kimos, one usually speaks of the Vazimbas as the primitive inhabitants of the great island. These Vazimbas, the "masters of the earth," who in legends are sometimes confused with the dwarfs just mentioned, are said to have constituted a gross, ignorant and poor people localized of old upon the highest plains, and of which, it is sometimes asserted, there exist a few survivors. Menhirs, standing in large numbers in Ankova, are sometimes called the tombs of the Vazimbas. Excavations well conducted at the foot of these monoliths would teach us more as to their authors than all the legends and all the remembrances of the Malgashes.

If we possess no positive document as to the archaic races of the old Madecasse territory, we are fortunately better enlightened as regards the populations, which, in this island, as in the majority of those of the Great Archipelago of Asia, form the second of the ethnic stratifications, distinguished by special observers under the name of "Indonesian."

The term Indonesian, which, in its elegant conciseness, very happily designates everything proper to the Indian Archipelago, has been applied for some years in ethnology, as well as in linguistics, to people and to dialects forming a great subdivision with firmly fixed contours in the vast Malayo-Polynesian ensemble, and the limits of which extend from the foot of the eastern Himalaya to the last of the Sunda Islands. All these Indonesian peoples exhibit a large number of physical, intellectual and moral characters that we find again more or less intact in all the Malgashes. Their languages, in particular, resemble one another in a striking manner and form a large, methodically classified family. Now, all the Malgash peoples, without exception, speak an Indonesian dialect allied to the Battak of the Sumatra, according to Muller, and which, from the south to the north of the island, exhibits only simple changes of pronunciation. Besides, the Malgashes have in common certain traits of manners, certain usages and certain habits borrowed likewise, more or less markedly, from the seas of the East. For example, while the Caffres and the Hottentots make mantles of ox hide, called "kaross," or war skirts of woven strips of panther skin, the Malgashes pound the bark of the hibiscus or weave the fiber of the rafia. The most essential instruments of the household, the rice mortar and pestle, the bamboo water vessels, etc., are all similar from Java to Madagascar.

Other instruments still, the musical ones particularly, are the same here and there; and although the very simple use of the war conch can be explained by inventions discovered isolatedly upon widely spaced territories, it is impossible to accept an explanation of this kind for the "valiha," a sort of very complicated guitar which is found identical at Madagascar, Timor and Laos. The sounds of this instrument are produced by the vibration of thin strips adroitly detached from the surface of a bamboo, but remaining adherent at their extremities. A small bridge raises them, and the place that it occupies measures the length of the vibrating rod. There is here, then, an extremely complicated and entirely special invention. It is impossible that the savages should have succeeded in conceiving it isolatedly and in applying it in an exactly identical manner. The makers of the valiha of Laos, Timor and Madagascar, however distant they be at present, were of old in contact, and consequently recognize common origins.

Many other details of Malgash life would carry us back to the lands of the East. Tattooing by pricking, unknown to the Africans, who practice incision, is sometimes done in Madagascar. We know that the use of it was formerly general in New Zealand, in the Marquesas and in the Pomotoo, as well as at Laos and in all Japan.

The "fody" or Malgash interdict is nothing else but the Polynesian "taboo." The nasal salutation is common to Madagascar and the islands of the Pacific, and it is only among the Antanosy of Fort Dauphin, so long occupied by the French, that people are seen to embrace each other instead of smelling of each other, as everywhere else. The foot salutation, a token of vassalage among the Malgashes, is described at length in D'Entrecasteaux on the occasion of the competitions of the great chiefs of Tonga.

Finally, for it is necessary to stop in this long enumeration of proofs, the funeral rites offer the most striking similitudes. They consist of singular and repugnant practices, into the details of which I am forbidden to enter here, but which Mr. Grandidier has made known in a long special memoir. We therein see, among all the tribes of Madagascar, the funeral divided into two very distinct periods. The first is devoted to the decomposition of the subject. In the second, which follows at a longer or shorter interval, the skeleton is buried alone, freed from the soft parts.

These usages are met with, with local variants, from one extremity of the Malayo-Polynesian world to the other. The Maoris of New Zealand, for example, expose the body of their chiefs in the open air in a large sarcophagus wide open at the top, and it is only when nothing is left but the bones that the box, which has become tabco, is burned and that the skeleton is buried in a cavern or in a volcano. In the center of the Celebes, among the Topantunuasu, the coffin is first laid upon stones in the forest, and, one year afterward, the rice crop having been gathered, the bones are gathered, cleaned, covered with oil, wrapped in "sarongs," and finally deposited in a grotto.

The sarcophagus is identical among the Sakalaves and in the Philippines. Here is a tomb all entire brought by Mr. Germinet from Nosy Loapasana, a small island of the bay of Diego Suarez, and here is another from Marinduque Island, to the south of Luzon. The two sepultures are the same. Both here and there they consist of a chest hollowed out of the trunk of a tree and closed with a cover in the form of a roof ornamented with a carved crocodile, an animal equally venerated in both countries.

I have said enough, it would seem, to show you that Madagascar all entire possesses a common ground, ethnographic and linguistic, which has nothing of African, and which reproduces languages, manners and aboriginal usages identically. We are, therefore, authorized to seek to distinguish in the Malgash population in general such characters as may be in accordance with those ancient origins demonstrated by linguistics and ethnography. Unfortunately, incessant crossings pursued for ages with peoples of very diverse origin conceal, in great part, these Asiatic characteristics, which we find only with much trouble among the Sakalaves, in particular, of the southern and western coasts.

These Malaisian physiognomies appear, upon the contrary, often well preserved among a relatively recent people, which, in Madagascar as in Sumatra, Java, etc., composes the third ethnic stratum, equivalent to the Malaisian stratum of the great islands of the East, and that probably came into our island toward the same times in which started from Menang Kabon the great migration that has distributed itself through entire Sunda. It would be impossible to assign a date to this first appearance of the Malays in Madagascar; all that can be certified is that they had remained up to the moment of their exodus outside of any Mussulman propaganda.

These Malays of Madagascar are the Antimerina, better known since Le Gentil, under the incorrect name of Hovas, who, to the number of from eight to twelve hundred thousand, inhabit the high region of Imerina or Emyrne, and who dominated a large por-

* Lecture delivered at the Museum of Natural History, Paris.

tion of the island at the moment at which we finally decided to put an end to their encroachments.

We have just said that the term Hova is incorrect. It is, in fact, a caste name. According to Mr. Grandidier, it is the equivalent of "citizen" or "plebeian," in contradistinction to andriana, which means "noble." The name of the nation is Merina.

It was not till toward the end of the eighteenth century that the Merinas began to take a place in the history of the great island. They appear as a small people, superior in intelligence to the neighboring tribes, able to forge iron and weave fabrics, but profoundly divided by intestine quarrels that prevent it from acquiring a development commensurate with its qualities.

The primitive habitat of the Hovas was in the southeastern part of the island. They afterward occupied Menabé, whence they reached the highest plains. They relate in their narratives that they successively conquered these various regions. The Sakalaves tell this story in a very different manner. According to them, the Merinas were driven from the fertile regions toward Emyrne, which is more healthy, but much more desolate.

Divided into tribes that were hostile to each other, the Merinas were, as I have already said, incapable of rising from their inferiority. United under the domination of an able prince, Andrianampoinimerina, they invaded the contiguous territories on all sides; and this obscure chief of a small canton of Emyrne, but lately tributary to the Sakalaves of the south, left, in 1810, to Radama Mandjaka, his son, an already powerful kingdom in which were united all the small Merina principalities and a great part of the Antsianaka and Betsileo peoples.

It would take too long to retrace here the history of this monarch's reign. We know how the intrigues of Chardenaux and Lesage caused the young chief of the Antimerinas to enter into a British alliance; how Sergeant Hastie, of the garrison of Mauritius, and the English agent Pye obtained greater and greater influence at the court of Tananarive, and how, finally, in 1817, the annexation of the country of Tamatave extended the domination of Emyrne as far as to the sea.

The Hovas were firmly established at Tamatave, at Foulepointe, Pointe-Larree, etc., when the government of Charles X decided on the expedition of 1829, the result of which was the establishment of a military point at Tintingue, unfortunately abandoned in the wake of the revolution of July.

The uncertainties of our colonial politics have, since then, left the Hovas every facility for aggrandizing themselves, and, at the present time, aside from the Sakalaves, who have remained in great part independent, there remain free people in Madagascar only in the southern portion of the island, beyond Tulear and Ihosy.

Let us rapidly examine the character of the Hovas or Merinas, in taking, if you please, as a type of the fine and brilliant race, Ambassador Ramaniraka, whom we saw close by at Paris in 1884, and of whom we have an excellent portrait, photographed at that time by Nadar.

Ramaniraka, second ambassador of the queen, is a true Andriana, a noble of pure breed. His hair is black and smooth; his color is of a light bister yellow; his head is globular and is pointed behind; his face is rather broad, his nose is short, with dilated nostrils, and his almond eyes are slightly drawn outwardly. His upper jaw is somewhat sloping, and the incisors, quite large in proportion, are implanted somewhat obliquely. He is a true Malay, upon the whole, whom one would have difficulty in distinguishing amid the islanders of Madoura, with whom Mr. Grandidier compares the Hovas more especially. Let us hasten to remark that the Hovas are, in general, far from attaining the distinction and elegance of our model.

No less eager than the Japanese, Siamese and so many other Orientals to imitate the Europeans and to give themselves the appearance of civilization as much as possible, the personages of Imerina are wont to dress themselves out in gorgeous and ludicrous cast-off clothing; and I might show you a whole collection of fantoccini disguised, one as a senator and another as a church beadle, who are no other than very high functionaries of the court of Antananarive.

You will remark, while admiring their laces, that several of these excellencies of color possess certain characters that reveal nigritic mixtures. It is not very rare, in fact, that the prime minister, the husband of the queen and sovereign master of the country, jealous and suspicious, substitutes the son of a slave for an andriana who has displeased him. Thus it was that Ramaniraka, of whom I have just spoken, an intelligent and enlightened man, who returned from his trip to Europe with a certain prestige, saw himself replaced in all his functions and had to depart in exile to the distant country of Ihosy, where Mr. Catat found him undermined with fever and slowly wasting away.

The more we descend the scale of grades or honors, to the number of sixteen, into which all the Hovas are distributed, the more also the negro element assumes importance. The Hova or Merina emigrants were probably not very numerous in the beginning. They had doubtless quite a small number of women of their race with them.

Mixtures have therefore taken place with the peoples already strongly cross bred met with upon the southeast coast of the island and under the action of such crossing has been formed the mixed population of which I shall now present to you a certain number of subjects arranged, as far as possible, in an order descending from yellow to black. You will remark, on the way, the disappearance of all national ethnography. The "lambas," themselves, which were of old the triumph of the aborigines of Emyrne, are now imported, or, if they are made here and there, it is with the dyes of Europe, especially German anilines, that the most brilliant colors are given them.

All these Merinas that I have shown you are small. They have long, smooth or curly hair, skin of a light tan color, a relatively large brachycephalous head pointed behind, a face dilated crosswise, a high forehead, a short and habitually straight nose, thick and projecting lips, etc. They have the robustness and agility of the Malays, but not the endurance thereof, and their activity is sensibly inferior to that of the neighboring peoples, of whom, however, they have made slaves who perform for them any work that is somewhat fatiguing.

The two sexes differ in the first place by their style of arranging the hair, which is cut very short in the men, while in the women it is laboriously plaited in fine braids that are arranged in a dozen different ways. In case of mourning, the loose hair is allowed to float over the shoulders.

The man differs, besides, from the woman in a much more marked manner by his natural slenderness and elegance, which is promptly concealed in the weak sex by a precocious embonpoint.

Travelers tell us that they have the qualities of the Malays, as well as their vices. Their memory is excellent, they learn very readily, and we have recently seen one of them gain the title of doctor at the Faculty of Medicine. Their gift of speech is very extraordinary, and they often manifest an unexpected disposition for music. They are laborious, sober and frugal, and, finally, they have an innate respect for authority, the habitude of a rigorous discipline, an unbounded devotion to their chief, and a profound love for their country. These, as Mr. Grandidier observes, are qualities that are not ordinary, and to which the Hovas owe the predominance that they have so quickly taken over the other Malgashes. It is true that, per contra, complaint is made of the native duplicity, and of the crafty disposition that they have brought from Malaisia. Their vanity is infantile, and they are superstitious to the last degree.

Mr. Grandidier has clearly indicated the differences that separate the Hovas from the other Malgashes, and finds that they are the same as between Malay and Indonesians. "The Hovas and the Malays are, in fact, of weaker appearance and their type is plainly Mongolian. They have funeral rites other than those so characteristic of the peoples of Indonesian origin, although their adoration for their ancestors is just as profound. They bury immediately after death and relegate the tombs to a point not far from their sight, in concealed places, and they do not fear to evoke the remembrance of the dead. It is their custom to discard their name as soon as they become fathers and to take that of their children. Their language, while analogous, is less nasal, more complex and more perfect. Finally, their social institutions are stronger, and their states, generally more powerful, are ruled by chiefs belonging to a hereditary aristocracy whose authority over their subjects is so much the more real in that, according to an ancient custom, they take the advice of the people under grave circumstances, in the 'Kabary' or plenary assembly, at the head of numerous and well armed soldiers ready, if need be, to support the governmental propositions."

I have said enough to make understood the interest that specially attaches to this Hova people among all those that inhabit the island of Madagascar. An endeavor has been made to diminish its importance in some recent writings. It must be recognized that the English agents saw rightly when they relied upon this people to prevent our progress. It must likewise be stated that we ourselves have found no other element capable of being employed in the way of a counterpoise among the other very numerous races of which it remains for us to speak.

The Betsileos, who dwell to the south of the Marinas, are at least as numerous as they, but, from the beginning, have been drawn into the sphere of action of their restless neighbors. The Sakalaves, numerous tribes of which occupy the north and west of the island up to the river Saint Augustin, are perhaps also, numerically, the equals of the Hovas, but are very inferior to them in all other regards, and their concurrence is far from rendering our columns the services that we had promised ourselves.

Let us say a few words of each of these savages. To the majority of travelers, the Betsileos are Hovas somewhat modified in their physical characters. I have seen but one living Betsileo. He was a sort of mulatto, and the skulls from Infandana brought home by Mr. Catat prove that the negro element plays a considerable role in this series of specimens, eminently composite and without great ethnic value.

The Sakalavas, who, as we have just seen, occupy the entire north of the island and its east coast as far as to Onehali, consist of numerous tribes, some of which are important, such as that of the Antankara, which occupies the country to the north of the Bay of Antongil, and those of the Antsianaka, who are immediate neighbors of the Hovas to the north of Imerina. The situation of these people with respect to the African coast very easily explains how their country has become the seat of an important commerce in negroes taken from Sofala, Mozambique, etc., by Arabian freebooters. The first voyages of the Arabs to Sofala date back, according to the chronicle of Kilona, to the 4th century of the Hegira, that is to say, to the first third of the 10th century (about 1025). It is therefore at least 850 years ago that these intrepid slave hunters began to establish in Madagascar the entrepots of blacks, who, in accumulating among the Sakalaves, have so strongly blackened them.

The anatomical control instituted at the museum has confirmed this manner of looking at it, by putting in evidence well marked affinities with the Mozambiques in our series of Sakalave skulls. The studies of Mr. Virchow at Berlin have given like results, but still more marked. The morphological control, of which I can more easily submit the different elements to you, permits of recognizing, amid quite a large collection of portraits of Sakalaves, a few scattered types belonging to the ancient Indonesian race—Anghy, for example, a Sakalave girl of Vohemar, aged 20 years, and then a series of other youths photographed by Dr. Collomb, and whose long and smooth hair in the first becomes curlier and curlier in the following, while the features become darker and darker. The tribes of the east coast, among which are found more particularly yet than elsewhere the Oriental affinities that I have already pointed out in a very general way, are likewise much imbued with African ethnic elements, and it will suffice to convince you of this to place before your eyes a series of portraits of Betsimisavakas, Betanimines, etc., who moreover sometimes offer the great interest of representing cross-breeds very similar to those that analogous crosses between Malays and Paponas have produced in the lost islands of Sunda. I call your attention in particular to the affinity that I have been able to establish between two Betsimisavakas and two aborigines of Timor of the Lapicque collection. The African negro element has given among the first, in combining with the old Indonesian, results entirely comparable with those that are due among the second to the crossing of the Papona with the modern Indonesian.

One of these tribes of the eastern shore, that of the Antaisaka, which is very numerous and very dense, appears to be the prolongation, seaward, of an important people of the interior, the Baras, which also, in preserving manners that are more or less Malaisian among its chiefs, has seen its mass profoundly transformed. This Baras people, which was hardly known before Mr. Catat's voyage, is a robust one of high stature, often of a deep black, with the flat nose, thick lips and the woolly hair of the negro. It is differentiated from all the other Malgash peoples by a strange style of dressing the hair, in which the latter, rolled into a ball and covered with a layer of white earth mixed with grease and cow dung, forms concentric crowns around a sort of central top knot. These Baras are great fetichists, and inhabit villages of a very peculiar aspect formed of square board houses surrounded with hedges of cactus closed with thick doors. Mr. Catat devotes an interesting chapter to these Baras, to which I refer my hearers, who at the same time will read with real interest all that concerns the Antanosy and the other peoples of the south, among which we shall now seek the traces of a lost ethnic element that it is yet necessary isolate before finishing this long communication. I mean the Semitic element, which has, at various epochs, mingled itself with the Indonesian and negro elements. Among these Semites there have been distinguished Jews who of old, under the name of Zaffebrahin, son of Ibrahim, or Abraham, inhabited Sainte-Marie, called by them Nosy-Braham. The invasions of the Arabs have been more widely extended. I have already recalled the intervention of the Arabian navigators at Sofala. In the fourth century of the Hegira, a certain Raminia is said to have led to the southeast coast a first band, whose descendants, the Zafi Raminia, to-day govern the Antanosy. Manifest traces of their intervention have remained, as you may see for yourselves, in the physiognomy of the natives, and Mr. Catat has brought us from the vicinity of Fort Dauphin some skulls in which the Semitic character is indisputably shown. A second band, led by Marabouts in quest of proselytes, founded, much later on, the kingdom of Matisana, among the Antaimoro, so well studied in recent times by Mr. Gabriel Ferrand. Finally a third series of ancient establishments, intimately connected with those of the Comores Islands, manifests itself on the northwest coast by the existence of ruins, the most interesting of which were discovered by Captain Marin Darbel in 1885. In the island of Mandza, Bay of Mahajamba, this distinguished officer visited some quite extensive edifices, of Arabian style, into the construction of which entered, in the way of inlaid work, very ancient Chinese plates certainly anterior to the Tartars. This discovery repeats in the north of Madagascar those of George Revoil at Mogadixo. It is the last link of a long chain of observations that starts from the Philippines and ends at Mandza, connecting all the ancient commercial stations of the Arabs, staking out in a way the stations of their commerce with the far East in the middle ages.

In order to omit nothing, I should have to speak of the merchants of India, who were attracted to Madagascar from time to time by their business, and of the Malattas, who are crosses with the whites, and whose role, it must be recognized, has been singularly exaggerated. Finally, I might, perhaps, be reproached for saying nothing of those brave colonists of Auvergne who, after two centuries, have preserved their manners and their accent in the mountains of the south!

It is necessary to be content for the moment with the very imperfect picture that I have just sketched, and to finish by expressing the hope that a great mission that will comprise an anthropologist and an ethnographer among its members will soon furnish us with the elements of a complete monograph of the populations of Madagascar. The superiority of the Malays over the other peoples of the island will always show itself greater there, and after peace is once established, one will think of finally regulating the fate of these few million aborigines attached definitely to the domain of France, and anthropology will be in a way to proclaim without hesitation that it is not upon the negroid savage that we ought to found anything, but that we must rely upon the Malay, as barbarous as he may have remained under his thin varnish of civilization. Upon turning the arm toward the great islands of Asia, the cradle of a good part of our new subjects, science will show what a colonizing people have been able to draw from the near relatives of our Malgashes in the Dutch Indies.—Revue Scientifique.

THE LOCAL ORIGIN OF THE AURORA BOREALIS.*

By W. H. WOOD.

THE author found that calculations based on the cosmical theory of the aurora borealis gave results inconsistent with the facts of observation, by placing the objects at such great distances from the observers as to preclude the light from reaching them. Also he found that the streamers do not show any variation in angular amplitude, nor in the intensity of the light at the various observing stations, however distant or near to the assumed region of verticality, but the objects, on the contrary, present the same appearance as to distance from each and all those places. It is often objected against these facts that the observations are not carried out scientifically. It can be shown, however, that a display of aurora borealis is formed in a number of centers over a given tract of country. The various auroral figures constitute local groups having many features in common, but which can be differentiated, and their identity disestablished by the presence of a physical order of differences permeating the group and by the variable factors. A comparison of the radiant points of the streamers obtained from a set of observations will show a remarkable difference in the amount and in the direction of the inclination

* Abstract of paper read at the meeting of the British Association at Ipswich.

of the streamers at each place of observation, proving the distinct group. Again, the time of maximum phase has been observed to travel across England from the east coast to the coast of Ireland in 2¼ hours, the earliest phase commencing at the east coast and falling 10 minutes later in a series of successive stages across the country. The time of maximum phase at one place has been found to coincide with the time of minimum phase at another, maximum being defined as the period of the greatest number of auroral figures in sight, and the minimum phase marking a period of their absence. An ocular proof of the above was stated as follows: An auroral object visible in Manchester failed to be simultaneously seen at Birmingham, and also could not be seen 5½ miles north of Birmingham. The streamers also vanish under telescopic view, indicating dispersed points of light near at hand. Clouds and rain usually follow displays of the aurora, as reported from all stations. This the author considers due to electrical discharges. As an experiment in support of this, if a column of steam has its shadow cast on a whitewashed wall, and a current of electricity is passed through the steam, the shadow will be noticed to deepen and assume an orange-brown color. This change is due to the coalescence of the minute particles of the water in the vapor. This is analogous to the change effected in the rain clouds region by the aurora. Spectroscopic examination of the aurora shows indices of oxy-hydrocarbonic acid gas and argon corresponding to an electrical condition of moist air.

The author concludes that the plane of illumination is at right angles to the direction of the horizontal current, the plane being illuminated on the south side only in these northern latitudes.

COSMOGRAPHIC APPARATUS.

THE apparatus figured herewith gives the different motions of the earth around the sun. In it, the axis or the earth is vertical, as is also the axis of the world that traverses the sun and is oriented from north to south; the celestial equator, represented by a circular plane, is horizontal; and the celestial ecliptic, represented by an elliptic plane, is oblique and inclined upon the celestial equator by 39° 27'. Moreover, the earth, which revolves upon itself (diurnal rotary motion), now rises above the sun on the north side, and now descends below on the south side, and describes around it an inflected ellipse of which the sun occupies the southern focus (direct annual motion). When the earth ascends it approaches the sun, and when it descends it recedes from it, thus marking a perihelion and an aphelion, a mean distance, two summers, two winters and two equinoxes different from one another —all things that are not represented in any ordinary apparatus, and which render this one entirely different from and preferable to any other. All the circles seen upon the surface of the earth and upon the celestial vault—the equator, the tropics of Cancer and Capricorn, the Arctic and Antarctic polar circles, the celestial ecliptic, the zodiacal band and the colures of the solstices and equinoxes—are reproduced upon the surface of the sun.

The rods that are fixed upon the sun indicate, when prolonged, the place where the different circles of which we have just spoken are situated.

The gilded sun may be removed and be replaced by a lamp provided with a globe. The effect of the sun's light at the different seasons will then be seen upon the surface.

The apparatus is accompanied with a special cosmographic map, which is placed beneath the foot of the instrument of which it is the horizontal projection, and also with a metallic ecliptic similar to the special map and which sets into the celestial equator.—La Science en Famille.

THE TESTING OF DIAMONDS.

NOTHING in nature is oftener looked for and more easily found than the diamond, and many supposed finds prove disappointments. The fine diamond should be clear and pure as rock water, perfect in shape and not only pure white, but lively, showing fire, as it is termed. Any undecided tint of brown, yellow, gray or other color is a positive blemish. The simplest test to identify the diamond is to hold the stone firmly against a wet, rapidly revolving grindstone for from five to ten minutes. If the least mark appears upon the piece, it is not a diamond, for if it were a diamond, so far from any mark being produced on it, it would be likely, on the other hand, to make a deep impression in the grindstone. The same test may be made with emery paper, or an emery wheel, neither of which, although harder than a grindstone, will make any impression upon a diamond.

We often hear it said that a number of different stones will cut glass. The truth is that only the natural edge of a diamond crystal will cut glass, while many stones, such as the sapphire, ruby, quartz and even common paste, will scratch it.

Some diamonds exhibit an abnormal degree of hardness, especially some very beautiful black ones from Borneo, which cannot be ground or polished by anything but their own dust, ordinary diamond dust frequently having no effect upon them at all. One of these was made the subject of special experiment by Babinet, of Paris, in behalf of the French Academy of Sciences. It showed great resistance to the polishing wheel, and the process of preparing it took a very long while.

A similar experiment was made in this country in 1885 and 1886 by myself at Messrs. Tiffany & Company's, New York. The stone here was a round piece of Brazilian bort, with a radiated internal structure. It was kept on a polishing wheel made of hard iron with a diameter of one foot for seven and one-half hours a day for nine months, the wheel turning at the rate of 2,500 to 3,000 revolutions per minute, and giving three feet of traveling surface to the stone.

The total distance traversed was 170,000 miles, or about seven times the circumference of the globe, but the result was the polishing of only about one square centimeter of surface. With an ordinary diamond fully a hundred times as much would have been accomplished.

Diamonds vary widely in hue; the purest are perfectly colorless and transparent, but they are found in almost every color of the spectrum, the commonest being white, yellow or brown, yellowish green, bottle green and, rarely, rose red, blue or black. Next to the yellow-greenish, yellow diamonds are the most numerous. The black are very rare, and when the diamond is between the brown and the black, its transparency entirely disappears or is seen only at the angles.

Perfectly colorless diamonds come from the mines of India, Brazil, the Cape and Australia. Perhaps about ten per cent. of the crystals which come into the market are colorless or of pure white; one-fourth are of fair color, with a flaw or spot of color, and the remainder are off-colored, called second quality, or by-water. Nearly one-half is only bort.

Colored diamonds exhibit their luster and clearness best when cut, especially the yellow ones, which by artificial light are very brilliant. Stones either perfectly colorless or having decided tints of rose-red, green, or blue, are most highly prized. Fine cinnamon and salmon tints, or brown, black, or yellow stones, are also esteemed. If flawless and without tint of any kind, they are termed "first water." If they possess a steely blue color, at times almost opalescent, they are called blue-white. Such are usually Brazilian stones.

Exceptionally perfect stones are termed gems, and for such there is no fixed value, the price depending on their purity, perfection, and brilliancy, freedom from flaws. It is impossible to estimate the value of a diamond by its weight alone, as color, brilliancy, cut, and general perfection must all be taken into account. Of two stones, both flawless and weighing ten carats each, one may be worth $600 and the other $12,000. Exceptional stones often bring special prices, whereas off-colored or imperfect stones sell at from $30 to $75 a carat, regardless of their size.

As the diamond is a cold substance, a mist is formed by breathing on it, and the mist being white, enables us to detect any color in the stone; or if the stone is unset, it may be placed on a sheet of white paper and breathed on, and while the mist is clearing away the faintest trace of color, and even flaws and imperfections, if visible to the naked eye, will become apparent. If the stone is unset and we fold a sheet of paper and look down on the side of the stone, we can trace any color that exists within, for the same reason that a piece of plate glass when looked through appears deep green on the ends. A small pile or paper of diamonds will show color, whereas a single stone may

COSMOGRAPHIC APPARATUS.

appear white to the unpracticed eye; as likewise a sheet of plate glass one-fourth of an inch thick and one foot long is seen to be green, though a piece one inch square appears white, the color in both cases being condensed in the quantity.

For this reason off-colored diamonds are frequently cut with a very low, flat crown (the part of the stone above the center). This disguises the color, though at a loss of brilliancy.

In many diamonds the interior of the crystal, the core as it is called, is not clear, but shows greenish or blackish spots, particularly in the green stones. Many have also "feathers" and fissures, which impair the passage of light.

By means of chemical agents and a high temperature, Barbot claims to have succeeded in removing the coloring matter from rough diamonds; green, red and yellow stones becoming perfectly colorless, while the dark yellow, brown and black gave up very little of their color. This seems scarcely possible, though M. Barbot, on the title page of one of his works, styles himself "Inventor of a process to decolorize a rough diamond." De Boot made the same claim in 1608, and in 1880 the English government granted a patent for the same process.

De Boot says that his imperial patron, Rudolph II, possessed a secret which enabled him to clear any diamond of flaws and color. No such process is now known, and a fortune would await its discoverer. It is claimed that some yellow diamonds turn pink upon heating, like topazes, but, unlike them, resume their former color after a time.

The diamond is one of the gems most readily identified by the eye, and it is next to impossible to deceive an experienced dealer. Let one of several imitations, or even such precious stones as white topaz, sapphire, beryl, phenacite, etc., be put among a lot of thousands of diamonds. While a dealer is counting he can at a glance detect the false ones and throw them out without missing the count, even if he is counting three at a time, more rapidly than bills could be counted.

The various tests described by the press, such as the use of acids, files, etc., are never resorted to by the jeweler. More persons than would be supposed know diamonds, and, once having worn them, one is not likely ever to wear paste through deception. It must also be said that the danger of buying imitation stones is not so great as that of getting diamonds worth not one-half their price, owing to inferior quality.

The fact that the diamond can be burned was first observed by Cosmo I, of Tuscany, in 1691. He used a powerful lens concentrating the sun's rays, and found that in that heat the diamond was consumed. Previous to that time it was believed that this hardest of all stones was indestructible by either acids or fire. If inclosed in a retort or crucible from which air is excluded, it does, indeed, seem unaffected by any amount of heat that we can apply, but if air or oxygen gas be admitted, and the temperature be raised to a point that corresponds to 5,000° of Fahrenheit's scale, the diamond will burn like coal, uniting with oxygen to form carbon dioxide. It is also proved that if a diamond be heated in a crucible with iron, the latter is converted into steel by union with the carbon of the diamond.

There is another variety of diamond carbon that differs greatly from the gem form, being brown, grayish black and black; this is known as black diamond, bort, bortz, carbon or carbonado, and is entirely distinct from the crystalline form.

Then there are rounded masses, with a greasy luster, and an imperfect radiated crystalline structure within, apparently made of a twining of many cubic crystals, white, gray to black and translucent. These are called round bort, and are found in irregular masses with no crystalline form or aspect. Both these forms are obtained in the province of Bahia, Brazil. Round bort has varied from $8 to $20 a carat within the past fifteen years.

All these are valuable for their cutting power, and command good prices, though the African or Cape bort, as it is called, is less esteemed than the Brazilian carbonado, because its crystalline structure renders it liable to break or cleave under strain: yet it is used in sawing marble. Both carbonado and round bort are harder and tougher than crystalline diamonds, and are less dense, owing, probably, to a porous structure, or to minute cavities. A fraud has, at times, been practiced with these materials by coating them with lampblack and wax, which produced a fine compact black appearance and increased the price, the wax being sold at the price of the best grade of carbon.

Its great hardness gives the diamond, in all its forms, a high importance in the mechanical arts. The poor, flawed and imperfect crystals, the fragments and cleavages, and the powder produced by crushing them are all used for cutting, polishing and engraving precious stones, glass, etc., but the hard, black varieties, bort or carbonado, are extensively employed in larger operations. What is called the diamond drill, invented by Lesshot in 1860, has revolutionized the methods of tunneling, mining and well-boring in the course of a few years. The general idea of it is a steel tube of the size desired for the boring, say from one to eight inches in diameter, on the extreme end of which are fastened a number of small pieces of bort. By means of suitable machinery, this tube is then rotated, pressing against the rock to be penetrated. The result is that the tube rapidly cuts its way into the rock, making a smooth, circular hole; while a rod or core of the rock passes up inside of the advancing tube, and is removed piece by piece as it rises. These cores are often of great value, as exactly showing the kind and thickness of rock traversed in any such working; and drilling in mining and engineering operations is frequently resorted to simply for this purpose. It was due to diamond drills that the Mont Cenis and other great tunnels were completed in a few years' time.

At the great salt deposits of New Iberia, La., the company desired to ascertain the depth of the mass of rock salt, and sank a boring for the purpose. The drill penetrated through 600 feet of solid salt, the cores furnishing the evidence, and 30,000 feet can be drilled in a perpendicular line.

Tools with diamond edges are used for "truing" and grooving the faces of emery wheels and grindstones; for truing the faces of hardened steel, rubber, porcelain, granite, celluloid, and calender rolls; for truing the inside of casehardened cylinders for gas engines; for cutting all kinds of glass; marking tempered metal, glass, stone, etc. It is easy now to sink artesian wells to far greater depths, and at far less cost, than would be possible without the diamond drill.

Another similar application has lately been announced. A thin circular disk of steel several feet in diameter is set with a number of pieces of diamond or bort, firmly brazed in place and distributed over its sides. This disk, when rotated, forms a circular saw of great power, which will cut through large blocks of hard stone very easily, and at very small cost. For sawing sandstone, granite, and other hard stones, the diamonds are brazed into the edges of a straight blade of iron, which gradually cuts the stone while it is drawn back and forth.

The name "diamond points" or "diamond sparks" is given to small natural diamonds used for glass cutting; "diamond splints" (commonly called "writing diamonds") are small cleavings of diamonds put into a metal handle and used for writing on glass and other hard substances.

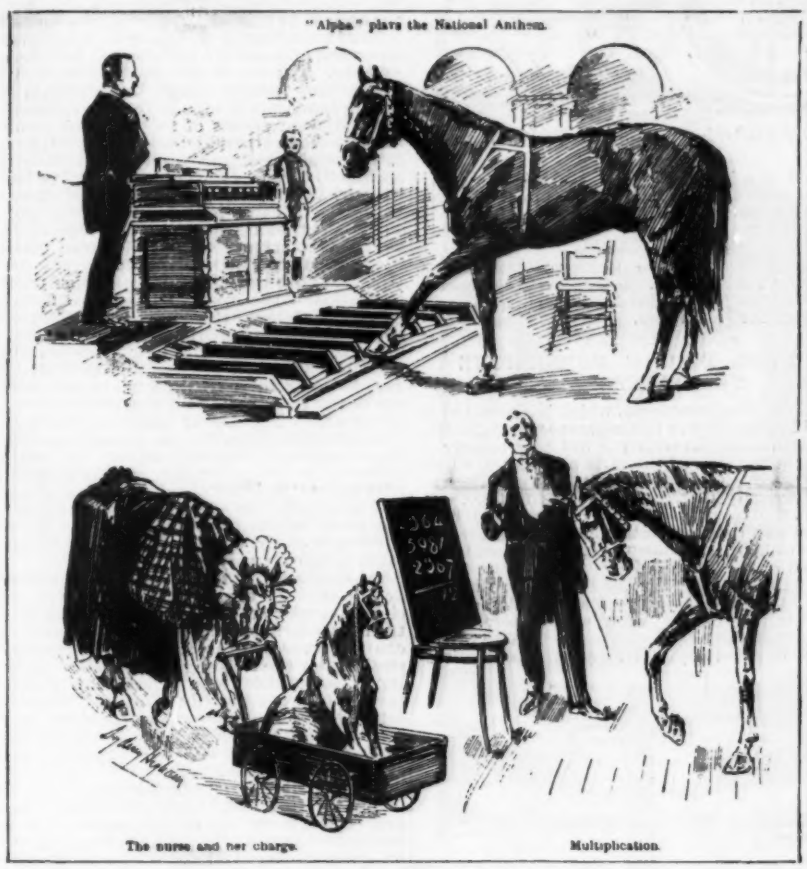
"Slabs" are thin cleavage plates of diamond that are drilled with minute holes of various sizes and used for drawing fine gold, silver, brass, and iron wire; a single slab will draw miles of wire. These are now successfully made by D. D. Palmer, of Waltham, Mass. Thin "slabs" are drilled by charging a fine iron point with diamond dust, which frequently requires weeks of time.

The name "diamond dust" is applied to the material that falls from two diamonds when rubbed together in the cutting process, or to bort itself when it is crushed, to be used on soft iron wheels for slicing and engraving precious stones, glass, metal, and other substances.

A very curious and interesting fact is the occurrence of diamonds, or, at least, of diamond carbon, in meteoric stones and irons—those visitors to our earth from interplanetary space. Diamond was first discovered in a meteorite at Novo Ureii, Russia, some ten years ago, and in 1891 its presence was recognized in the meteorite found at Canon Diablo, Arizona. It was detected by Dr. A. E. Foote, described by Profs. Koenig and Huntington, analyzed by Friedel, and finally, its hardness tested by Dr. Huntington and myself. As a conclusive test we subsequently polished two diamonds with the powder taken from the meteorite in the Tiffany cutting exhibit at the World's Columbian Exposition in September, 1893.—George F. Kunz in the New York Sun.

AN EDUCATED HORSE.

A REMARKABLE animal is now to be seen at the Royal Aquarium, London. The "Human Horse," it should at once be explained, is not a physical monstrosity of any kind, but an exceptionally interesting example of animal sagacity. With care and kindness on the part of the trainer, and keen perceptive powers on the part of the pupil, it would seem possible to educate a horse up to almost any pitch. Alpha, as the horse is named, is a good looking light chestnut, thoroughbred, quick tempered, and about six and a half years old. He comes, with his trainer, Mr. Shaw, from Boston, Lincolnshire. A miniature pony, Beta, by name, completes the party. Beta is an impudent looking youngster, easily able to stand beneath its more dignified companion. When seen together—and they appear to be great friends—the two animals form an attractive picture. Alpha's intelligence, however, is the feature of the show. He plays the harmonium, writes his name on a slate, guiding the pencil with his mouth, and is not even averse from a quiet game at "Nap" with the audience. Arithmetic and the ordinary accomplishments of a properly educated horse are trifles to him. In fact he has been trained to do almost everything except to talk, and the horse has got over even that difficulty with a deaf and dumb language of his own. To see Alpha play the National Anthem is alone worth a visit. An arrangement of keys has been made for him at the foot of an ordinary harmonium, and Alpha, after walking up to the instrument with his roll of music between his teeth, proceeds to play the familiar air with his feet. This he does correctly from beginning to end. The performance comes to a close with an amusing scene, in which Alpha—quaintly



AN EDUCATED HORSE.

dressed as a nurse—trundles a perambulator along containing baby Beta, who sits there as composedly as any self-respecting nurse could wish.—Daily Graphic.

REVERSAL IN INVENTION.*

By EDWARD P. THOMPSON.

THE products of the human mind are to the science of invention what the earth is to geology, or isolated facts to physics, or animals to zoology. The century is about to close with a countless number of inventions, which may have their use in building up inventive science as well as in aiding commercial progress.

Invention as a science has not received the same attention as physics, for example. When a new fact is disclosed in the latter there is usually a place for it, because it falls under some broad principle; but when a new invention is made, it stands as isolated as one whole science does from another. Inasmuch as many facts are needed to establish a principle, it is intended mainly to present sufficient inventive facts to show the great probability of an inventive principle so far recognized, if at all, only as a fact. The single word reversal serves, perhaps, as well as any to designate one principle, and accordingly it will be spoken of as the inventive principle of reversal, which is not only useful in adding to the science of invention, but, by proper effort, should be applicable in the production of new inventions.

Men are slow to learn principles in any science, and they are correspondingly backward in any attempt to apply them, but as soon as some one shows their practical applicability, others follow, and a rush of progress ensues. The object of this article is first to make positive once for all the principle of reversal, and, secondly, to emphasize the importance of its systematic application to all inventions, past, present, and future, especially all leading inventions. One man cannot do this, but many men can, and this principle will doubtless live forever.

As the first fact to be reviewed, let the most important and perhaps the most wonderful, be considered. As to the dynamo and the electric motor, the one was known for a long period prior to the other, without any one's knowing that a reversal of the operation of the one would create the other. No one thought of applying the principle of reversal, and few, if any, clearly perceived its existence.

History shows that the change came about by a great deal of mathematical calculation, suggestions and combination of circumstances, but now we see that it might have come about by applying this principle of reversing the operation. The application of this principle should be sought in all inventions in order that no such wonderful results may be escaping our notice. Who knows at present but that steam could not be generated by mechanical power by the principle of reversal applied to a steam engine? Imagine steam generated by the power of Niagara Falls! This experiment of applying the principle of reversal to the steam engine may have been tried without the writer's knowledge. It is here used as an illustration, and was conceived by the author by the application of the principle of reversal. In the same manner the application of the principle should be attempted with regard to all present inventions of leading types and to certain new inventions as they appear.

By this method, if a new invention or result is obtained, it will not be by accident, but because of predetermined repetitions of the application of an inventive principle disclosed by the study of prior inventions. Having learned this lesson of reversal, let no further inventions of this kind wait for an accident, but let it be an instrument of the mind working upon present and each new invention. Nor is the dynamo motor the only known invention which might have been made by the application of this inventive principle; there is also the telescope of the sixteenth century as a reversal of the microscope made before the first century, in the sense that the one makes a distant object appear nearer, but not as large as in reality, while the other causes a near object to appear larger than it really is. At the time the microscope was invented, therefore, the principle of reversal could have been applied by reasoning that, if a distant large object could be made to appear nearer, could not a near object be made to appear larger? Had this idea been created, the mechanical execution could have been carried out by experiments with lenses of different convexities, concavities and numbers.

A reversal of the telephone, which causes distant sounds to appear near, would be a microphone, but the present instrument is improperly named, as it does not enlarge, but simply creates a sound. When first invented its wonderful power was spoken of as making the walking of a fly sound like thunder, but this is false, because the fly jarred loose carbon electric contacts, thereby causing great fluctuations of current and violent action of the receiving telephone.

If the hand jarred the contacts, the sound would have been the same. The speaking trumpet is a reversal of the telephone, as the microscope is of the telescope, but by no means to such a degree, for the microscope will bring to sight animals which are otherwise invisible, while no microphone has ever been made which reaches the enormous corresponding power of the microscope. The sounding board and ear trumpet are the nearest approaches to a true microphone, but they do not enlarge the sound. They do not make a near sound louder. They merely make a sound heard as loud as it really is, but no louder.

However much this reversal or microphone may be desired for detecting the humming and singing of the invisible insects which are exposed by the microscope, and however much a better microphonic stethoscope is desirable, and however curious we may be to hunt for small sounds which are thought not to exist, we probably shall never have a true microphone, because it appears, according to our present knowledge, contrary to the principles of mechanics, as it would require a creation of force, because sound is the effect of force. In the microscope light is not created, but scattered, while the image—something intangible—of the real object deceives the eye, which considers the image the real object. The ear may be deceived as to the direction of a sound, and as to the nature of its source, but as to intensity the ear has never seemed to hear a sound appreciably louder than it really is.

The present air brake system is now recognizable as a reversal of the early type, but a long time passed before the change took place. The principle had not been used as a kind of tool, and, therefore, the idea of the new brake did not come by demand of the mind, but by a combination of circumstances, that is to say, accidentally. The two systems of brake referred to are perhaps already conjectured by the reader, the first operating to stop a train by the positive action of compressed air against the wheels through the medium of the usual brake shoes, and the second by the negative action of compressed air, which normally holds the shoes away from the wheels in opposition to a spring. The advantages of the second way are apparent as soon as compared as to their main object, safety; for by the former the train cannot be stopped in case of leak or a disordered pump, while with the latter the train stands still as soon as the air leaks out or the pumps refuse to work. The method of hastening the progress of this class of invention cannot be too thoroughly grasped. By its use accidents may be anticipated; at least, it seems so; but it cannot be definitely decided until an actual attempt is made and success obtained. The whole matter seems about as simple as this. Suppose the ferry boats crossing the Hudson River at New York and the tugs and coast steamers and other vessels should suddenly drop their rudders, but continue with full steam and sail. By the theory of probabilities, all the vessels might escape collision; by means of the rudders the escape is almost certain, because of predetermined means applied for definite ends. This principle of reversals is, therefore, comparable to a rudder, for by testing its application to existing inventions, it is almost certain that if any process not so far reversed to advantage is thus reversible, and yet unknown to be so, or hidden, the principle of reversal will disclose it. The simplest case of reversal is that illustrated by the ear trumpet and the speaking trumpet, the reversal consisting in changing a tapered tube which is applied in one instance to the mouth of one person for intensifying the effect of the sounds upon the hearer's ear to the opposite process of applying the tube to the ear to intensify the sound coming from a speaker with or without a speaking trumpet.

The mental process of investigating this subject makes the principle so simple that it is a wonder that inventions existed so long before their opposite phases were thought of. Electricity furnishes several examples besides the dynamo motor example, where the principle was not applied by a predetermined act. The old form of burglar alarm had an open circuit and the process of opening the window closed the circuit and rang a bell. The reversal of this is a normally closed circuit. The opening of the window breaks the circuit, and the bell rings. The idea once gained, and the advantages are apparent, for an alarm is given if the burglar cuts the wire.

By making a reversal, and then comparing the two, the advantage appears, but the accidental process is a slow one, being brought about by thieves cutting wires and entering successfully; then a condemnation against all alarms, and then experiments, numerous devices to prevent the cutting of wires, and finally a bright idea of the closed circuit, nobody, not even the inventor, knowing whence it came.

The tempering of steel or glass by heating and quickly cooling admits of the reversal of heating and cooling slowly, an invention forming the basis of the whole steel and glass industry.

The present "safety" match is the reversal of the phosphorus parlor match of 1847, in which the potassic chlorate and red phosphorus were mixed with friction before ignition, while in the case of the "safety" they are mixed by friction during ignition. In the one, the chemicals are kept together until wanted and in the other they are kept apart till wanted. Before Bottger's invention, in 1855, many fatal accidents and fires had occurred, because of the use of the earlier type of match. After an invention has been made, of course, no one is able to say whether it would have been made earlier or not by some systematic effort, but allowing for reasonable doubt on this point, as is fair in all logical reasoning, the conclusion is reached that if the principle of reversal had been on record and properly established by numerous examples, and if the given invention had been immediately analyzed as to the process of obtaining a lighted match, and then this process simply reversed and tested to learn the truth of the mental reversal, the safety match would have been the immediate result of systematic effort without a lapse of seven or eight years for the right combination of circumstances to occur in behalf of its birth.

It is not argued that all inventions are made by the use of the principle of reversal. There are other principles which may be treated of later. The process of application of the principles is comparable to that of assorting corks. Those that fit a certain bottle are retained, while the rest remain to be tested by a different standard. How wonderful it would be if by this purely mental operation a new and invaluable invention should be obtained. The mind of man has created great things, but as yet probably not any by means of the successful application of a predetermined principle to existing inventions.

The storage battery, although condemned for railway traction, is still one of the valuable inventions of the day, and is an exact reversal of the galvanic battery. The reversal is disclosed by stating that the operation of the primary or galvanic battery consisted in placing metal plates in a solution of salt or acid, and carrying off the electric current by a wire. The reverse

* From the Journal of the Franklin Institute.

of this consists in starting with an electric current, after the battery is partly exhausted, and passing the current through the solution in order to restore the chemicals to their original composition, ready to give off current as before the charging. History shows that this reversal was conceived almost contemporaneously with the primary type; for the Philosophical Transactions for 1800 contain a picture of Volta's pile, the first battery known; and in 1801, Gautherot conjectured the reversibility and Ritter a little later investigated it, and went so far as to use plates of the same metal, while Planté, in 1859, finally succeeded in finding the best solution (dilute sulphuric acid) and the best metal (lead) to be employed.

The present commercially successful and widely employed electrical converter or transformer, invented only about ten years ago, involves the application of the principle of reversal of the induction coil invented many years earlier. In this modern invention we are impressed with the remarkable oversight of the reversibility, in itself so exceedingly simple; for the device in both instances is the same, consisting of two coils of wire close together, but insulated from each other, one being constructed of a long fine wire and the other of short thick wire. It had always been the practice to pass through the coarse wire any kind of low potential vibrating current, such as an intermittent, undulatory, or alternating current, and to make use of the high potential current which became induced in the fine wire. The reverse of this is to start with any given high potential vibrating current and to pass it through the fine wire, and thereby obtain a low potential vibrating current. How exceedingly simple! We could almost blame a child for not trying it. The only explanation is that no one thought of it. Now that so many examples are discoverable, and a true solid principle of reversal, and not simply a theory, is established, let not reversible inventions be longer hidden.

Electroplating is the reversal of the galvanic battery, for the latter consists in obtaining a current by dissolving a given metal and the former in recovering the metal from solution by passing a given current through the solution. The apparatus and materials are the same in both. In the one, the metal is given and then disappears. In the other, the current is given and then disappears. However, history indicates that the invention was not made by the application of this principle of reversal. To show that it could not be made in that way as soon as the galvanic battery was made, and not several years later, suppose that electroplating were still unknown and we proposed to apply the principle of reversal to all leading inventions, and we arrived at the different forms of the galvanic battery. We would notice that the process with the simple battery consisted in placing two conducting solids, such as metals, into a conducting liquid, and in permitting the current to pass from one metal to the other. One of the metals would dissolve and a current would be generated, i. e., chemical energy would be converted into electrical energy. The reversal of this process would be to take a current from another source and pass it back again in the reverse direction and notice if the metal were recovered. If the experiment succeeded, it would be considered a wonderful discovery, and still more wonderful, because made by the wonderful, mysterious, and invisible mind as the first cause. The discovery would be followed by the ordinary process of scientific investigation of the effect of the current upon all metallic solutions, acids, and metals arranged to form cells. One man's conception, as above outlined, and a few weeks of experiment would, according to logic, have reached the deposition of gold or silver upon the baser metals, and would, therefore, not have required from 1801 till 1840 for electroplating with silver and gold to become a fact. In regard to the value of the inventions produced by this method of reversals, it is certainly interesting to note that reversed inventions, as apparent from the examples, are among the most valuable. Several of them are at the basis of a new art, as, for instance, the one just mentioned. The electroplating industry is one of immense proportions. The philosopher's stone could have been but little less wonderful, for both practically produce gold and silver objects for cheap materials.

As recently as 1856 Bessemer reversed the very old process of making steel, and at present practically all rails for railways are made by this process, besides all boilers and all kinds of large steel articles. The old way consisted in adding about 5 per cent. of carbon to pure iron, usually called malleable iron, by heating the iron in the presence of carbon. He reversed this step by taking pig iron, which is rich in carbon, and removing all but the right percentage of carbon, by blowing air through the heated pig iron so that the carbon might be united with the oxygen of the air.

THE ELECTRIC TRICYCLE.

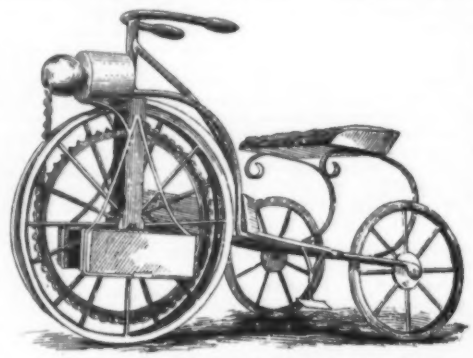
THE accompanying engraving represents a novel electric motor vehicle designed by Mr. Charles H. Barrows, of Willimantic, Conn., and described as follows in the Electrical Engineer. As will be seen, the vehicle is of the tricycle form, but unlike all other motor vehicles of this type the forward wheel is the driving wheel. This wheel is made up with one hub, two sets of spokes, and two rims with solid rubber tires. Between the two sets of spokes is securely fastened a large sprocket rim carrying a sprocket chain, which engages with the very small sprocket pinion of an electric motor carried at the base of the steering spindle of the bifurcated post which straddles the driving wheel, and in which the wheel is journaled in ball bearings. The gearing has a speed reduction of 14 to 1.

The current is obtained from a primary battery contained in two cabinets each 24 × 8 × 8 inches which are disposed one on each side of the driving wheel supported in the center by a foot piece at the lower end of the bifurcated post, and at the ends by supporting rods reaching down from the shoulder over the wheel. This battery weighs 100 lb. and has a normal output of 35 amperes at 30 volts for 10 hours and is capable of giving 50 amperes for a short time, thus making available a little over two H. P. The long leverage of the gearing between the motor pinion and the driving wheel gives a fast speed electric motor an advantage three to one in weight over a slow speed petroleum motor for a given speed of the vehicle.

This combination is claimed to be equivalent to at least four horse power required to drive motor vehicles of 1,500 lb. weight. The entire weight of the Barrows vehicle built to carry two or three passengers is only 300 lb. Its speed can be varied from a crawl up to a mile in three minutes, and it is at all times under as perfect control, and in the same manner, as a trolley car.

The carriage part of the vehicle is a slight structure consisting of a simple framework with a wide comfortable seat and two pneumatic tired wheels hung in ball bearings. Each wheel is independently journaled, whereby all extra friction on curves is avoided. Steering is accomplished by means of a handle bar similar to the handle bar of a bicycle. Our illustration is made from a photograph of a rough model and does not show the perfect finish and symmetrical form of the machines which will be soon finished.

The front wheel of this vehicle being the driving wheel, and carrying within itself the entire locomotive force, makes practically a mechanical horse, attached to the carriage in its rear, by tube and spindle in the



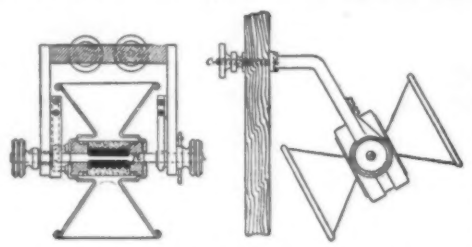
THE BARROWS ELECTRIC TRICYCLE.

same manner as a bicycle; this horse, as it were, may be detached from one carriage and hitched to another in one minute, and will work as well in a sleigh as in a carriage.

One filling of the cells, it is claimed, will run the vehicle from 100 to 150 miles according to condition of roads and the load carried. Enough of the concentrated solution may be carried for a 500 mile run, at a cost of 50 cents for recharging.

THE NISSL DOUBLE MICROPHONE TRANSMITTER.

THE Nissl double microphone, which is illustrated in section and in side view in the accompanying illustrations, has been designed with the object primarily of preventing the packing of the carbon granules, which has proved such an annoying inconvenience in the past in the majority of transmitters of this type. As will be seen, the two microphones are mounted back to back and one can be substituted for the other by turning the thumbscrew shown at the side, the motion being limited by a stop pin. By employing two transmitters they can be used alternately, and the motion of turning serves to shake up the granules, and to maintain them in the best working condition. It is also urged for this double microphone that the person telephoning is not compelled to use the same micro-



THE NISSL DOUBLE MICROPHONE.

phone which has immediately before been used by another person, a desirable thing, both from a hygienic and an æsthetic standpoint.—Ztsch. f. Elektrot.

CAR HEATING BY ELECTRICITY.*

By J. F. MCELROY.

THE general principle employed in the construction of electric heaters is that of placing in these heaters suitable resistances which become heated by the passage of the electric current. In the Burton heater, one of the earliest electric heaters tested on the electric railways in America, a resistance wire, made of German silver, was bent in a zigzag form and placed within the hollow space between two iron castings. The wire was embedded in powdered fireclay, and the castings bolted together. These two castings, which together formed the casing or outside of the heater, had a roughened surface for the purpose of enlarging the radiating surface. It was claimed that the embedding of the resisting conductor within a powdered mass of fireclay prevented the air from reaching the conductor, and hence prevented its destruction by oxidation when exposed at high temperatures of air.

Oxidation in a resisting conductor may be retarded if it is possible to keep the oxygen of the air from reaching the surface of the conductor, but in such a construction results may be reached which are just as objectionable as the oxidizing of a conductor by contact with air. The embedding of a resisting conductor in powdered fireclay, or other material which, from its very nature, would be classed as a non-conductor, would retard the escape of heat. The objectionable result is then reached that the temperature of a conductor rises to such a degree that the life of the conducting material is soon destroyed. Other electric heaters were put upon the market, but much difficulty was experienced, either from the oxidation of the resisting conductor or from its destruction by fusion when inclosed in a mass of material, such as is shown in the Burton heaters.

High temperature is one of the conditions leading to the destruction of the resisting conductors, and while this difficulty is not experienced at 300 to 400°, it is always experienced when the metals are heated to a temperature of 900° to 1,200° Fahr. Another condition is the crystallization of the conductors at high temperatures, and this is specially the case with German silver or any alloy. It is not necessary to run near to either of these danger points. The temperature of the resisting conductor depends upon the amount of heat which that conductor gives out per square foot of its surface, and the total amount of heat would, therefore, depend upon the number of such units of surface which there may be in the conductor. The reduction of temperature in the resisting conductor may be carried to any extent by simply decreasing the amount of actual surface in the resisting conductor, its temperature thus being reduced to a point where the conductor is absolutely safe and its life is permanent.

In the construction of the heaters made by the Consolidated Car Heating Company, of Albany, cylindrical porcelain tubes are threaded upon a $\frac{5}{8}$ in. square iron rod, the tubes having on the surface a spiral groove, which runs from end to end. A porcelain dish is placed at each end of the heater, and when desired one is placed at the center to furnish a support for the binding screws, to which the ends of the resisting conductors are attached. No. 20 B. and S. galvanized iron wire is coiled in the form of a close and continuous helix. As this wire is wound by a machine in the form of a continuous coil, just so much of the wire is separated in forming a coil as gives just the proper resistance. These coils are then placed in the groove which runs spirally round the porcelain insulators. Care is taken to stretch out the coil sufficiently to prevent adjacent spirals of the coil from coming in contact with each other, and contact with that part of the coil in neighboring grooves is prevented by ridges separating the grooves on the porcelain. The result is that the wire is thoroughly insulated, and short circuiting within the heater itself is prevented, and still it is wound open so as to present its whole surface to the air. It is so arranged, too, by its even pressure upon the porcelain insulator, that no part of this coil can vibrate, and hence there is no danger from the crystallization of the iron wire while hot from tremor or vibration of the heated wire. This feature of this heater is a very important one, as it absolutely prevents the crystallization, and hence breaking of the resisting conductor. These coils have now been operated for over three years, and not one coil has given out or has shown any oxidizing effect in the substance of the wire. The use of iron as a resisting conductor obviates the difficulties of crystallization, to which German silver is especially liable. The melting point of iron is at a temperature of nearly 3,000° Fahr., so that the temperature of fusion is so far above the normal temperature of the resisting conductor, and as vibration of conductor is prevented by the method of winding it on the insulator, no danger occurs from oxidation, fusion or crystallization.

It is important in the construction of electric heating devices that the expansion of the metallic wire due to change of temperature be fully provided for, and that the heater be so arranged that under no circumstances can the force of expansion and contraction create a strain upon the resisting conductor or upon the insulating parts which would be liable to injury, or to break them. This is especially important in conductors designed to be run at a high temperature, as the difference in length of the conductors at the extremes of temperature to which it is subjected is quite a considerable part of its length.

It is a well-known principle that a wire of a given length, if heated and then cooled, and again heated and cooled, is not the same length at the same temperature that it was in the first test. Changes will go on for some time in lengths of wires so subjected to heating and to cooling. On the other hand, care must be taken that under no conditions can the expansion of the wire make it loose on the insulator, and so cause a short circuit between neighboring wires. In a car equipment of the heaters just described the length of wire, when heated to the highest temperature to which it is subjected in the regular operation of the heater, is 7 ft. 5 in. longer than it is when cold. By the construction adopted this expansion is taken up between consecutive layers of the wire itself, so that expansion and contraction of the wires do not operate to vary the tension of the coil of wire, nor even to vary the pressure with which it binds the insulator itself.

The change of temperature in resisting conductors is attended with other phenomena, which should be considered in the construction of electric heaters. For example, it is well known that the resistance of a wire of a given material of given length and cross section depends upon the temperature at which the resistance is measured. Iron wire possesses certain qualities in its variation of resistance with temperature which admirably fits it for use in electric heaters. An iron wire having a resistance at 0° C. of 100 ohms has its resistance doubled when the temperature is increased to 180° C., and its resistance is increased to 500 ohms when its temperature is 525° C. The change of resistance in German silver is but a fraction of the change of resistance of iron wire.

The application of this favorable resistance in the construction of an electric heater is the automatic control which this property of iron wire gives over the temperature of the electric heater itself. If a non-conducting hood is placed over an electric heater, which prevents the circulation of air, the escape of heat will be prevented, and the temperature raised to a dangerous extent.

The use of the variable resistance, so marked in iron wire, is apparent, as its effect is to reduce the amount of current flowing through the heater, and hence to reduce the amount of heat generated. Two electric heaters, one of iron wire and the other of German silver, both having the same resistance at 0° C., and both being covered with a non-conducting hood, which pre-

* Abstract of paper read at the annual meeting of the New York Street Railway Association, held at Albany, N. Y., 17th September.

vents the escape of heat, would, as the temperature rises, act very differently. If the temperature rises to 300° C., only two-fifths as much current would pass through the iron resisting wire as passes through the German silver. This throttling action of the iron wire increases more rapidly even than the increase of temperature, so that at 600° about one-fifth as much current passes through the iron wire as through the German silver, and in each case the reduction in current means also a reduction in the amount of heat generated. A heater, therefore, provided with an iron resisting conductor has this advantage over that fitted with German silver, that if for any reason the escape of heat from an electric heater is prevented, either purposely or accidentally, the action of the rise of temperature upon the heater itself is to so throttle down the amount of current passing through it (and hence the amount of heat generated) as to prevent such a high temperature of heat as might prove dangerous.

Careful tests made with the thermometers placed against the grated openings, which the clothing of passengers might possibly touch, show that the highest temperature of the air is about 180° Fahr., owing to the free discharge of air up through the heater.

The proportion of electric energy transformed into heat in a conductor depends upon the resistance of the conductor. The electric heater is the only case that comes within our knowledge where 100 units of electric energy may be transformed into 100 units of any other one form of force. We can then establish the heat equivalent of the electric current for all electric heaters in which no disintegration takes place in the resisting conductors, one B. T. U. being produced by 1,047 watts of electric energy. We are constantly meeting with business men, as well as so-called inventors of electric heaters, who claim that some particular form of electric heater which they have devised will produce a greater amount of heat per unit of electric energy than some other form of heater. This is plainly impossible, so long as neither mechanical motion, chemical motion, light, nor magnetism is produced in the electric heater. Transmission of electric energy is, therefore, entirely into heat with an efficiency of 100 per cent. It is true that in some of the forms of electric heaters, a chemical action, resulting in the destruction of the heater, is produced by the electric current. Where chemical action takes place, the chemical action can be determined in units of energy; the efficiency, then, of that particular electric heater must be 100 per cent, minus the amount so transformed into chemical action. But where we have the wires of electric heaters running year after year, without any change of any kind appearing in these wires, it is evident that the efficiency may be regarded as 100 per cent.

It is an easy matter to determine the exact amount of heat which is produced in electric heaters when the consumption of current is known. For example, if we find the number of watts by multiplying the number of amperes passing through the heater by the difference of voltage of the heater terminals, and then divide the number of watts by 1,047, we will have as a quotient the number of British thermal units of heat generated in the electric heater per second. If we consider the electric heaters in a car to be using as a maximum 12 amperes of current on a 500 volt circuit, we will find that 12 amperes of current multiplied by 500 will give us 6,000 watts. Dividing 6,000 watts by 1,047, we obtain 5·73 B.T.U. of heat generated in the car per second. Multiplying 5·73 by 60 will give us 343·8 B.T.U. per minute.

Practical experience in the heating of cars has demonstrated that it requires about 20,000 B.T.U. per hour to properly heat an 18 ft. car in the latitude of New York State in the coldest weather, which amount of heat should be provided as a maximum. The average requirement during the winter months, when heat is used, would not exceed half this amount, or would be approximately 10,000 B.T.U. per hour. The amount of heat required, however, differs somewhat according to the construction of cars, to their exposure to winds on the line where they are run, and to the care exercised by conductors in closing the doors promptly when passengers enter or leave the cars. All of these are points which affect materially the temperature which will be maintained in a car with a fixed amount of heat. Also the number of people in a car affects quite perceptibly the amount of heat required. Crowded cars require less heat to maintain a given temperature than is the case with cars carrying but few passengers, due to the amount of heat given off from the bodies of passengers. Experiments made as to the effect of passengers upon the temperature of cars and houses have shown that each person gives out 191 B.T.U. of heat per hour. When we compare this amount with the average amount of heat required during the cold weather, we find that the heat given out by fifty-two persons will maintain the same temperature in the car as is required on the average during the winter months. This point has a practical bearing in the heating of cars, inasmuch as a car is heated uniformly, as with a stove, it would be found overheated during those hours of the day when the cars are filled with passengers. When electric heaters are used some lines have established the practice of reducing the heat between certain hours when their cars are filled with passengers. This would still allow a comfortable degree of heat to be maintained in cars, and at the same time would allow the use of the extra power for propelling cars at the time when travel is the heaviest. The next point in regard to electric heating is the regulation of temperature. As the temperature of the outside air during the heating season will vary from 50° to —15°, it is important that the electric heating apparatus be so constructed that the amount of heat given to the car varies so as to meet the demands of the variable weather. This is necessary for two reasons: First, it is necessary in order to maintain a comfortable temperature in the cars with variable conditions in the weather; and, second, it is important in order that the consumption of current shall be adjusted to the actual demands. Undoubtedly a great saving in the use of current is brought about by the use of apparatus that is provided with means for proper regulation.

A device introduced for the purpose of regulating the temperature of the cars, and by which five different intensities of heat may be obtained, corresponding to consumptions of current varying from 2½ to 12 amperes, operates by shifting the heating coils constituting the car equipment into series and multiple series, so as to vary their combined resistance, and hence to vary the flow of current through them. On small cars and in climates where comparatively a small amount of heat is required, an equipment consisting of four heaters is often used instead of six, as is the standard equipment. These four heaters are connected up with a three-point switch, which is so arranged as to place the heating coils in multiple or in series, so as to vary the consumption of current from 2½ to 8 amperes. The cost of heating cars by electricity is determined by the cost and quantity of current consumed. If the number of ampere hours on a 500 volt circuit can be once determined, and the cost of an ampere hour on the same circuit is known, the cost of running electric heaters can be readily ascertained. The question of cost, however, is not easily determined, as it still remains an open question as to just what items should be charged to electric heating. It would be but fair for a company considering the advisability of introducing electric heaters in their cars to consider, not the total proportionate cost of current consumed, but rather the additional cost of generating the current to supply the electric heaters, not charging to electric heaters such power house expenses as would continue the same, provided electric heaters were not introduced, but only the cost of the additional current. These costs have been carefully determined, based upon the cost of producing power by different types of engines, as contained in a paper by Dr. Charles E. Emery, in the "Transactions of the American Institute of Electrical Engineers" for March, 1893. From this it will be seen that the cost of operating electric heaters will depend upon the kind of engine employed and the cost of coal. For example, if coal costs $2 per ton of 2,000 lb., and if the average consumption of current in cold weather is 7 amperes, and if we take a compound low speed condensing engine as the average type of engine in point of economy in consumption of fuel, we

MAGNETIC CLOCK OF THE SEVENTEENTH CENTURY.

will find that 7 amperes for one hour will cost 1·17 cents.

From the reports received the average length of time a car is in service per day in the winter is shown to be fifteen hours. The cost of operating electric heaters with the average consumption of current in cold weather would, therefore, be fifteen times 1·17 cents, which equals 17·55 cents for fifteen hours. This cost does not allow for any depreciation in heaters, as the three years of service of the heaters here considered does not appear to have any effect upon the life of the conductors, and not a single coil in any heater has ever been renewed in this length of time. So far as examination of the coils that have seen three years of service can determine, absolutely no oxidation has been produced upon the wires Some allowance, however, should be made for repairs, when the amount of necessary repairs can be ascertained.

As to the cost of heating by stoves, a number of reports have been received from different railways in New York State using stoves. The list of questions submitted was designed to bring out as full information as possible in regard to the operation of cars equipped with these stoves. Several roads furnished reports, and where quantities are mentioned the figures given below are the average of the quantities stated in these reports.

Taking the average made in the answers referred to, it was found that 33 lb. of coal were used per car per day, costing $4.55 per ton of 2,000 lb. This coal costs 7½ cents per day. The average cost of repairs per car is ¼ cent per day. The average cost of dumping fires, removing coal and ashes before car is run out of barn, and coaling up and rekindling fire in the morning, including the cost of kindling used and that part of cleaning cars chargeable to stoves, is 10 cents per day. The average cost per day of other expenses chargeable to stoves not included in above, such as cost of removing stoves for the summer, installing the stove in the autumn, repairing head linings, repainting, etc., averages 1¼ cents per day. Without adding anything to the cost of the stove for the space for one person occupied by the stove, the total of the items so far aggregates 19¼ cents per car per day. It has already been stated that the extra cost of current based upon the cost of power necessary to heat a car with 7 amperes of current on a 500 volt circuit aggregates 17·55 cents per car per day. This amount will be modified as different types of engines are used; for the type of engine generally used it is correct. Other questions of greater importance enter, however, than the cost of the mere heating by electricity or stoves, such as the effect which electric heating has in inducing travel upon street car lines. It is, however, a difficult thing to determine in figures exactly what increase of travel takes place, on account of having cars properly heated at all times, and that heat being properly distributed through the car. This point is worthy of the consideration of managers of street railways in the matter of securing patronage for their lines.

The following is a summary of answers sent in reply to a series of questions regarding heating: Fire started November 15; discontinued March 24. Coal consumed per stove per day between dates mentioned, 26 lb. to 38 lb.; average, 33 lb. Cost of coal per ton, $4.25 to $5; average, $4.55. Number of hours fire is maintained per day, 17 to 24. First cost of installing stove, including smokepipe, smokejack, etc., $22 to $25, average, $23. Cost of repairs per car per year to maintain stove in working order, 17 cents to $1; average, 59 cents. It was stated in regard to the average cost per day of dumping fire, removing coal and ashes therefrom, before car is run out of barn, coaling up and kindling fire in the morning, including cost of kindling used and that part of cleaning car due to stove, that in some cases the work was done by watchmen without extra cost, and in other cases it was 20 cents per day; other expenses per day not chargeable in the above, as removing stove in summer, installing in winter, repairing head linings, repainting, etc., were said to be not over $3 per year per car. Seating space occupied by stove was said to range from that required by one person to 19 in. No objections were found by persons sitting next to stove. The replies to the question whether the heat was evenly distributed were: "Warmer in the center," "Fairly," and "Very little complaint." In answer to the question whether, if the stove occupied space of two persons, this seating capacity should be charged to the stove, two companies answered "No," and another replied, "Space of one person should be charged." The question whether dresses had been burned was answered in the negative. Three companies answered in the negative the question whether head linings and other part of car had been renewed on account of damage from the stove.

MAGNETIC CLOCKS.

THE origin of these mysterious clocks is very ancient. The clock of which Baron Grollier de Serviere has mentioned the existence, and of which Mr. Planchon has discovered the mechanism, is described in a little work, now very rare, Traité de l'Aiman, published at Amsterdam in 1687, by D——, an initial known by bibliophiles to be that of Dalencé. The text is illustrated with a large number of curious figures, which are very well executed, and represent different magnetic phenomena framed in landscapes according to the taste of the time. A part of the volume is devoted to the applications of the magnet to the construction of mechanical apparatus, and, among others, of clocks. To complete the description given by Mr. Planchon, we reproduce an arrangement no less curious, and the text that accompanies it.

"One may make a small dome supported by columns, and into the inside of the base of it may be set a circle of copper upon which the hours are engraved at equal distances. In the thickness of the dome, and behind the circle of hours, may be placed a magnet inclosed in another circle, which is movable in order that it may be revolved at will, either by a button or winch, so as to make the magnet come opposite any hour desired. At the bottom, between the columns, and just in the center, there should be a small figure holding in its hand a silken thread to the end of which is attached a small and very light bird made of very thin glass blown in a lamp and covered with down or small feathers. This bird should be provided with a bit of polished iron in lieu of a bill, and should be attached to the silk in such a way that it can approach only within two or three lines of the circle of hours. When it is placed opposite the hour to which the magnet corresponds, it will sustain itself in the air, and, if the magnet be made insensibly to turn, the bird will follow it and seem to fly in indicating the hours. (See the accompanying figure, in which the magnet is marked by dots and the letter G.)"

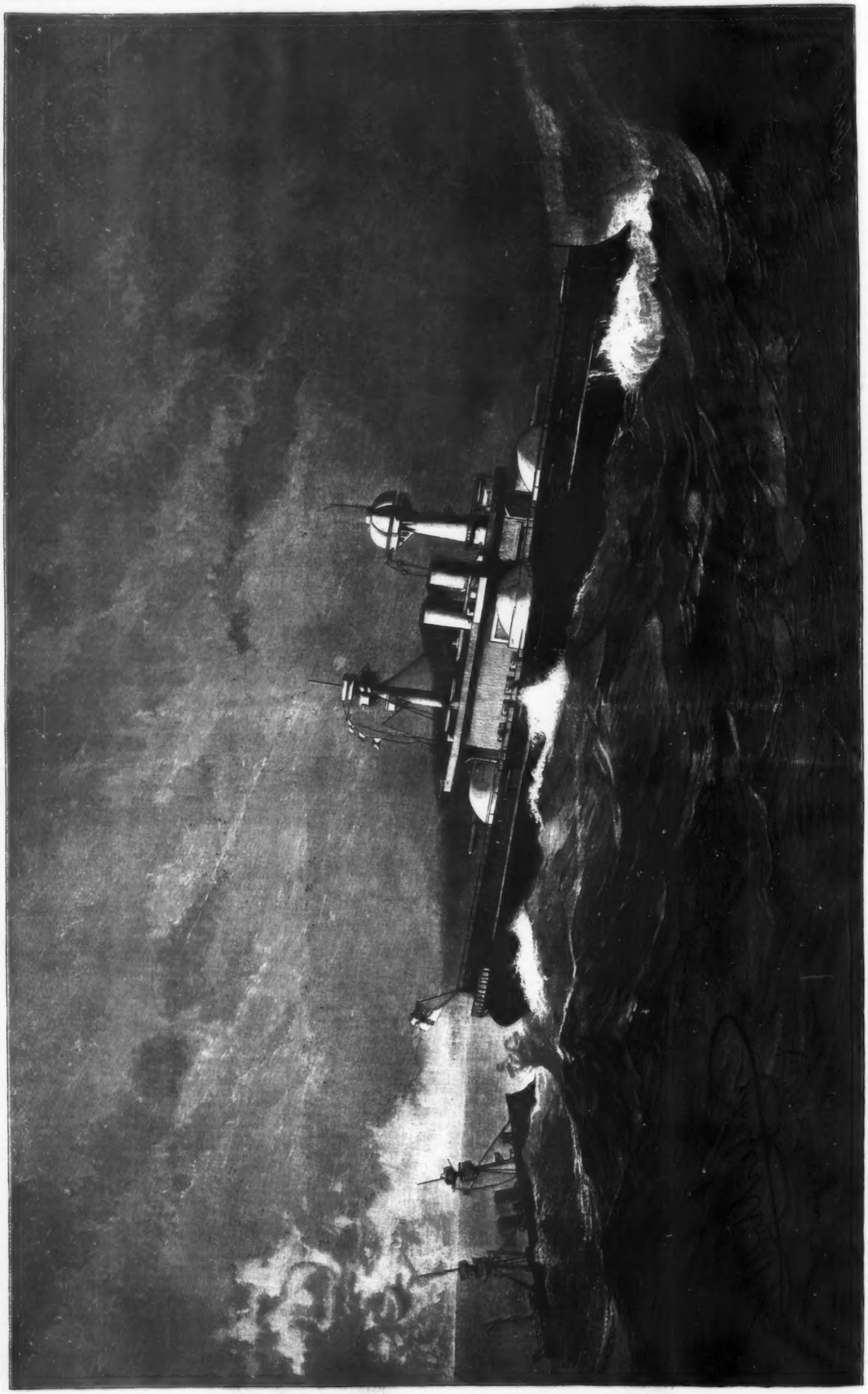
After describing several other arrangements in which the magnet plays an analogous part, and, among others, that indicated by Mr. Planchon, Dalencé remarks: "There may be added to these machines a clockwork movement that is to be hidden in the body of the wood, either in the dome, the circle or the gueridon, and which, causing the circle to which the magnet is attached to move, the bird, the needle and the frog that follow it will mark the hours as regularly as an ordinary dial hand."

Dalencé borrowed this idea from ancient authors, probably from Father Kircher, who, in his Magnes sive de Arte Magnetica, represents a similar experiment under the caption of the Dove of Architas.

The physicists of that epoch were very fond of devising and constructing similar apparatus, in which the properties of the magnet, unknown to the masses, played the leading role. It was for them both a diversion and an occasion of showing their science to the ignorant public of the period.—La Nature.

MR. HANS ZOPKE, a German civil engineer, commissioned by his government to look into the methods adopted in this country for the propulsion of cars by electricity, is in this city.

"I think America is far ahead of any other country in the use of electricity," said Mr. Zopke. "You have taken advantage of every invention and appliance that the minds of electricians have conceived, and in this are the leaders of the world."



GERMAN WAR VESSELS IN A STORM.

GERMAN WAR VESSELS IN A STORM.

THE accompanying engraving is interesting, not only from the fact that it places before us an artistic view of two important vessels belonging to the German navy, but more especially because the original was drawn by Emperor William II. Two years ago a bazar was held in Berlin for the benefit of a children's hospital on Heligoland, and among the articles that were contributed for this worthy object none attracted so much attention as a charcoal drawing by the emperor, with his signature. Our engraving is a reproduction of this picture, which was not a work of fancy, for in it the emperor brought together two vessels actually belonging to the German navy; one of the oldest and the latest addition. The latter, which is in the foreground, is the armored vessel Ersatz Preussen—not yet completed—of the so-called "Brandenburg Class;" that is, an armored vessel of the first class having a capacity of 40,000 tons and a crew of about 2,200 men. As the cut shows, the armor does not extend all along the sides of the vessel, but covers only those points whose protection is considered essential for its safety. The guns are no longer arranged in a long uninterrupted row; the heaviest ones are placed in towers, while the lighter rapid-firing guns, the revolvers and magazine guns are arranged in the most convenient locations. The torpedo devices are under the water line, and consequently not visible. The other vessel, the Kaiser Wilhelm, has a peculiar history. It was built in England for Turkey, and was to have been the pride of the Ottoman fleet, but as has happened before with the Porte, when the time of settlement came the money was not forthcoming, and the English firm of ship builders had to look for another purchaser. The opportunity was seized to obtain the vessel for the German—then the North German—navy, and it was purchased and the changes made that were necessary to fit it for the use of its new owners.—Ueber Land und Meer.

A NEW HYDRAULIC PROPELLED STEAM LIFEBOAT.

IT will no doubt be in the recollection of many of our readers that the Royal National Lifeboat Institution of England had for some years prior to 1888 been anxiously endeavoring to discover a method of propelling a lifeboat by mechanical means, and to this end offered rewards to competitors all over the world for models or drawings of a boat adapted to meet the conditions under which a lifeboat was called upon to do its work.

In response to these offers, several models and drawings of what were put forward as suitable boats were received and adjudicated upon by a specially chosen committee of experts in such matters, but strange as it may seem, not one of the designs sent in was deemed suitable for the particular duty such a boat would have to perform, and it was not until the following year that what promised to be a practical solution of the difficulties which had presented themselves in the design of an efficient boat was found in the construction of the hydraulic propelled steam lifeboat the Duke of Northumberland, built by Messrs. R. and H. Green, of Blackwall, and engined by Messrs. John I. Thornycroft, of Chiswick, and illustrated in our pages. The very successful preliminary and subsequent trials of this boat, and the good service rendered by her since she has been permanently stationed at Harwich, have helped to the conclusion now held, that she is the typical lifeboat of the future, and that no other system of mechanical propulsion than that adopted in her has yet appeared that can be practically applied in boats of her peculiarly special type.

In support of this contention, we have pleasure in being able to place before our renders the results of the trials which have just taken place of a new lifeboat, or an improved Duke of Northumberland, which has been both built and engined by Messrs. Thornycroft, of Chiswick. As this boat differs only from her prototype in being somewhat larger and more powerful, a description of the distinctive features of her hull and propelling machinery will equally apply to both vessels.

The boat referred to is named the President Van Heel, and she has been built for the South Holland Lifeboat Institution, from the designs and specification of Mr. G. L. Watson, Naval Architect to the Royal National Lifeboat Institution of England, and is of the following dimensions: Lengths, over all, 55 ft.; on the water line, 53 ft.; breadths moulded, 13 ft. 6 in.; over sponsons, 15 ft.; and over rubbing pieces, 16 ft.; the moulded depth being 5 ft. 6 in. Her fully loaded displacement is about 30 tons, the load consisting of crew, coal, fresh water in tanks, engines and boiler, mast and sails, and about 30 passengers. In the loaded condition her water draught is estimated at 3 ft. 3 in.

The hull of the vessel throughout is constructed of Siemens-Martin steel, and every seam in it is either double or treble riveted. It is divided into eighteen water tight compartments, and is strengthened by transverse and longitudinal bulkheads. Two of these compartments are occupied by the engines and boiler and two form the coal bunkers; each and all of which can be kept free of water, either by the main engine or the portable deck pump provided.

The propulsion of the vessel is effected by means of a nearly horizontal centrifugal pump, having an impeller 30 in. in diameter driven direct by a compound surface condensing engine having cylinders 8½ in. and 14½ in. diameter, with a piston stroke of 12 in. The pump is fed with water by a scoop-shaped inlet amidships, and it delivers through four outlets in the side of the boat—two for motion ahead, one on each side below the water aft, and two for motion astern, close under the sponsons, above water forward. The engines have no reversing gear, thereby saving much complication, weight, and wear and tear of machinery, and only run one way; the direction of motion of the boat being governed by the position of the valves in the discharge pipes of the pump, which are manipulated either from the engine room or by the steersman at the wheel, who by moving one valve only can cause the boat to turn on her center quite independently of the rudder.

The main and auxiliary engines of the lifeboat are supplied with steam by one of Mr. Thornycroft's patent water tube boilers, which has a heating surface of 610 square feet and a grate surface of 11·4 square feet, and is capable of maintaining, under a forced draught, an ample supply of steam at a working pressure of from 145 lb. to 150 lb. per square inch, with which the propelling engines will develop an indicated power of about 250 horses.

For steering, the boat is provided with a deep rudder, which is worked by worm gearing through an ordinary hand wheel and shaft, the rudder being fitted with an arrangement for tricing it up—when the boat is in shoal water—without interfering with the steering. To assist the propelling power, when making for a wreck, or for the shore, after leaving one, the boat is fitted with a mast forward of the boiler, hinged in a tabernacle, which when not in use is lowered and stowed over the covering of the machinery space. It carries when in use a lugsail and staysail. At the bow and stern ends—for strengthening purposes and for protection against the shipment of water—the boat is fitted with a plated turtle back covering or hood; the boat's deck proper, between the hoods, being covered with corticine to prevent slipping, and to preserve the plated deck beneath it from the action of the sea water. For warping purposes, and working the anchor, a steam capstan driven by an independent engine is provided at the after end of the engine room and in proximity to it. In the well of the boat is fitted a reel of 100 fathoms of flexible wire rope.

The President Van Heel, which was launched with her machinery and boiler on board, and steam up, having made a preliminary trial—which was very successful—directly she was put into the water, was on Thursday, September 19, taken down the river Thames to the Lower Hope to undergo a series of official speed trial runs on the measured mile and to be put through certain turning evolutions, to test her handiness and steering qualities.

Runs.	Time.	Speed in Knots.	First Means.	Second Means.	Mean Speed in Knots.
	M. s.				
1. With tide.. ...	5 41	10·557			
2. Against "	7 29	8·018	9·287	9·302	
3. With tide.....	5 39	10·619	9·318		
4. Against "	7 34	7·980	9·274	9·296	9·293
5. With tide.....	5 40	10·588	9·259	9·308	
6. Against "	7 23	8·129	9·357		

The morning of the day of trial being anything but propitious for the purpose, through the prevalence of a dense fog on the river, the boat was detained at the starting point—the North Woolwich Pier—for fully an hour, until it was deemed safe to proceed. At 11 a. m., however, she was enabled to be cast adrift from the pier and to pursue her way to the measured mile in the Lower Hope, which she reached at noon, her engines in the meantime having been gradually brought up to their full speed. Arrived at the mile, six continuous runs, with and against the tide, were made, and gave as their results those shown in tabulated form above.

The mean speed of 9·293 knots an hour attained by the boat, being that due to a developed power by the engines (when running at a mean of 449 revolutions a minute) of 220 indicated horse, the steam pressure in the boiler being 140 lb. per square inch, maintained with an air pressure in the stokehold equal to 2¾ in. of water. As the guaranteed speed of the boat was 8½ knots, in the fully loaded condition—the thirty passengers being represented on the trials by iron ballast—it will be seen from the above recorded results that that speed was exceeded by fully ¾ of a knot.

The speed trials over, the boat was then put through various turning movements, with and without the use of t e rudder; the results of which showed conclusively that the vessel is entirely under the control of the officer in charge without any communication with the engine room. Going ahead with rudder and engines the circle was turned in about half a minute, and the boat was brought from full speed ahead to dead stop in 10 seconds. The facility with which the turning movements were made was particularly remarkable, the boat responding instantly to the least alteration of helm, or movement of the valves controlling the water jets. As a final test, to determine how soon an assumed man in the water could be rescued from the drowning element, while the boat was moving at some speed, at a given moment a lifebuoy was thrown overboard, and it was found that the time occupied in putting the boat about and recovering the buoy was exactly one minute.

The results of the trials of the President Van Heel lifeboat were in every way a great success, and eminently satisfactory; and the representatives of the institution for which she has been built are to be congratulated.

The trials of the little vessel were attended by the chief officials of the two kindred lifeboat institutions we have mentioned, together with the representatives of the builders and engineers, who had charge of the trials and the machinery.—The Engineer, London.

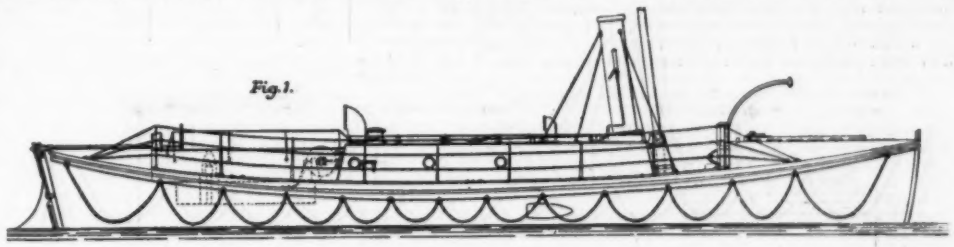


Fig. 1.

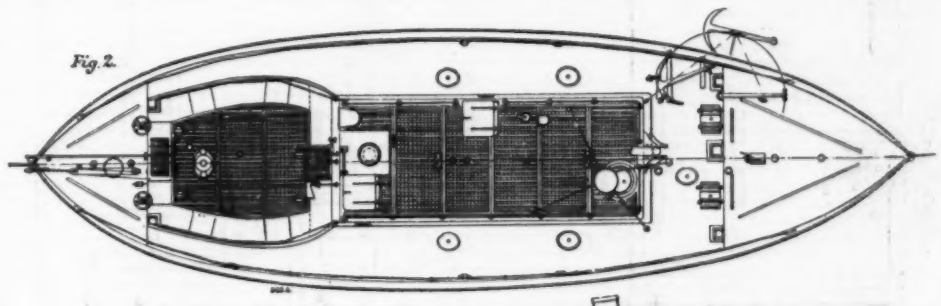


Fig. 2.

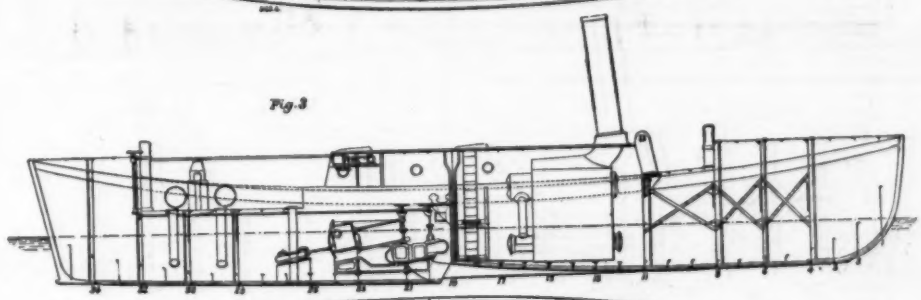


Fig. 3.

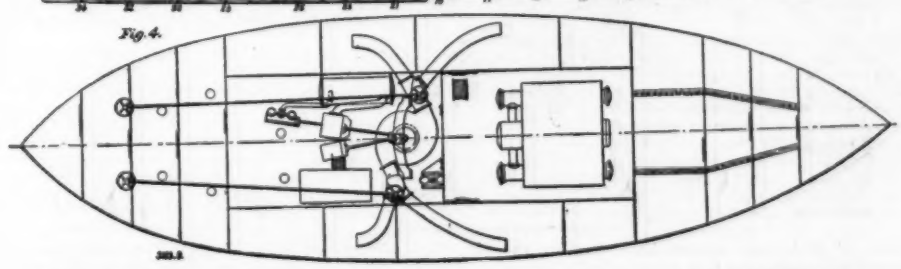


Fig. 4.

HYDRAULIC LIFEBOAT FOR THE DUTCH GOVERNMENT.

WATER SUPPLY ON BOARD SHIP.

IT is impossible to overestimate the importance of an abundant supply of drinking water on board steamers, especially those engaged in the passenger traffic or in the transport of troops. It has been found that the best method of obtaining this important requisite is by the evaporation of sea water and the condensation of vapor in special distillers. That there are many types of distilling plant at work on the principal liners is a matter of common knowledge, but a description of a new and very effective apparatus will, no doubt, be of interest to our readers.

This apparatus, which we illustrate on next page, where the same letters indicate the same parts, differs entirely from all fresh water producers hitherto constructed. It introduces a system which is original, interesting, and advantageous. As is well known, all ordinary vapor condensers consist of an arrangement

of copper or brass pipes, which are kept cool by the sea water being circulated around them, while the vapor passes through them. Such arrangements, from the heavy scale forming in them and other substances being deposited on the tubes, not only rob the circulating water of its cooling qualities, thereby lowering the efficiency of the apparatus, but at the same time increase the necessity for constant attention and cleaning, valuable time being sacrificed at each overhaul and in putting the several coils together again. To avoid these drawbacks—frequently experienced in tubular condensers—the apparatus we now describe has been constructed on an entirely new principle.

The distiller is formed by a number of plate elements, which are provided on both sides with channels cast of special form. Between the elements are placed thin tinned copper sheets, which shut off the channels of one element from those of the other. The channels of the different elements both above and below the copper sheets are connected by pockets, cast on one side of the elements, and by this means two entirely separate systems of channels are formed and kept asunder by the copper sheets already mentioned. If one of these channels is fed from above with steam, and the other from underneath is supplied with cooling water, the steam, viz., the vapor from the evaporator, and the cooling water, are moved along in perfect contact after the counter-current system, and in such a manner that an extremely energetic exchange of heat takes place between the two. In such transformation the highest efficiency is secured in a comparatively small apparatus, and a refrigeration of the condensate is thus obtained, which could not be secured in tubular condensers. The following data, which have been taken from practical working with the vapor at a pressure of 11 lb. per square inch, demonstrates the merits of the apparatus:

(a) Cooling effect such that the difference between condensed drinking water and the cooling water entering the apparatus was only ½° Fah. (1) Capacity per square foot condenser surface, 80 gallons of drinking water per 24 hours. (2) 100 gallons of drinking water per 24 hours are produced, with a condenser weighing, with water added, 42 lb. (3) Quantity of cooling water, about eight times as much as the condensate. Final temperature of cooling water, 194° Fah. (b) Cooling effect such that the difference between condensed drinking water and the cooling water entering the apparatus was 5° Fah. (1) Capacity per square foot condenser surface, 134 gallons of drinking water per 24 hours. (2) 100 gallons of drinking water are produced per 24 hours, with a condenser weight of 27 lb., contents of water included. (3) Quantity of cooling water, about eight times as much as the condensate. Final temperature of cooling water, 194° Fah.

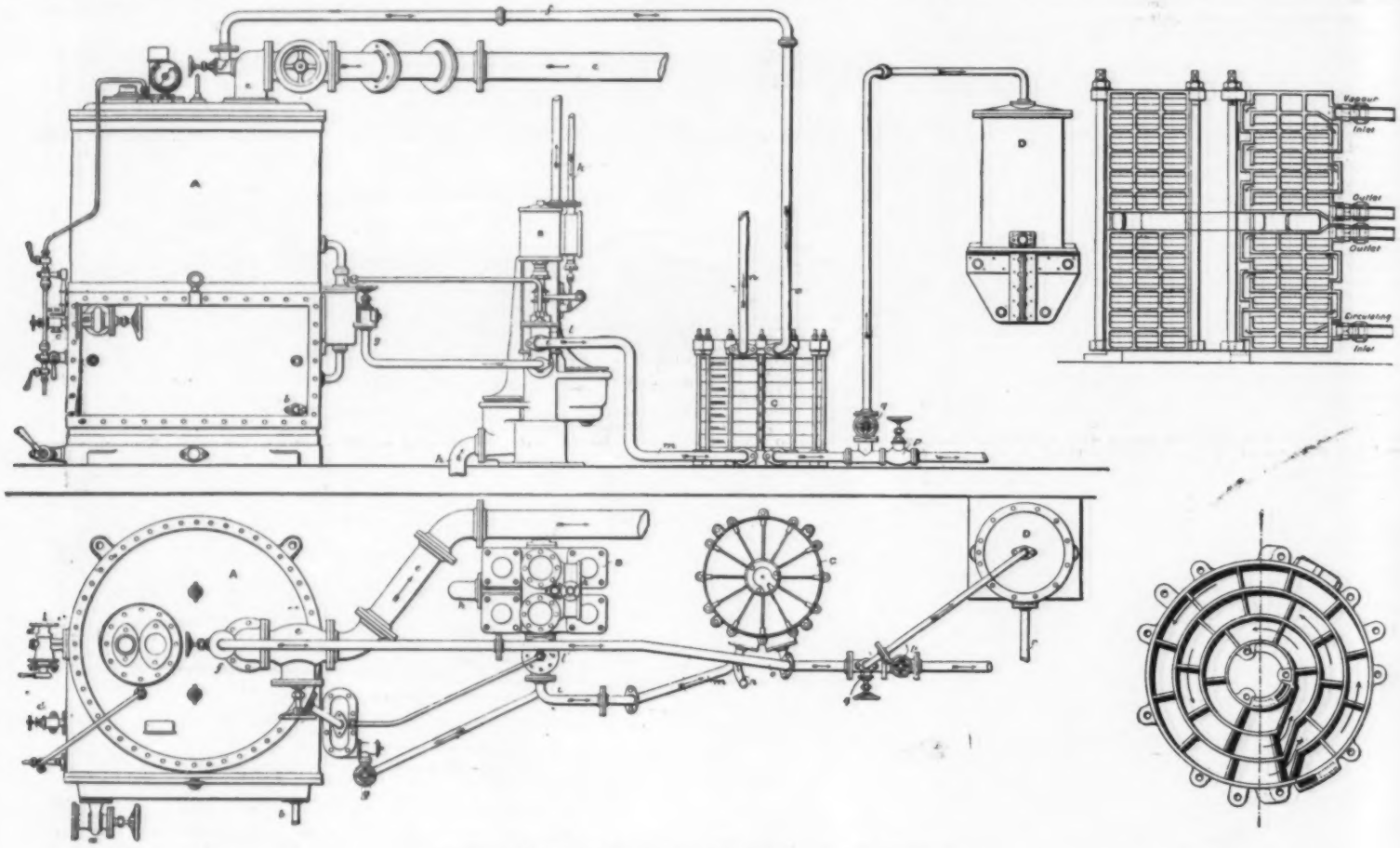
The foregoing results, which have been taken from some of the largest installations, show clearly the efficiency of the apparatus. The advantages claimed for it over almost any other can be readily ascertained. It has been found impossible to obtain such effects in tubular condensers, and moreover, from the fact that in the plate distiller the water in circulation is constantly moving at a high velocity, the efficiency is easily maintained. Further, in comparing the weights of the different types with their efficiencies, it is claimed that the plate system has the advantage in a most substantial manner. One of the most important, or what may be accepted as the most prominent feature in favor of the newly introduced system, is the perfect aeration of the vapor in its passage through the distiller. Owing to the violent process of condensation, and the rapid cooling of the condensate, it is found that all the air which is evaporated out of the sea water, together with the vapor, is fully absorbed by the condensate, which is then produced as a clean cool liquid having all the qualities and ingredients of natural water, with a taste almost equal to that obtained from a spring or well. It now becomes a question whether, if with even all the improvements possible, the tubular distillers can compare with the "Renown."

There is reason to believe that before long its adoption by many large passenger steamship companies will become an established fact. Already it has been adopted in war vessels and government transports. It has been introduced by the firm of Messrs. Maudslay, Sons & Field, engineers, and is being constructed at their works at Lambeth.

A glance at the following table should impress our readers with the high efficiency of the apparatus, when we notice that the temperature of the drinking water produced is practically the same as that of the cooling water employed for circulation, and the output in gallons compares most favorably with the size and weight of distiller required for the given quantities:

No. of apparatus.	Diameter.	Height.	Weight.	Capacity in gallons of drinking water per 24 hours, when difference in temperature between cooling water and distilled amounts to			
				1° Fah.	1½° F.	2½° F.	2½° F.
	in.	in.	cwt. lb.				
I.	14	9	1 53	200	260	300	340
II.	18½	12	2 85	340	500	550	600
III.	18½	19½	5 0	680	1000	1100	1200
IV.	28½	28	10 0	1300	1700	1900	2100
V.	28½	36½	14 0	1800	2200	2800	3100

In conjunction with the "Renown" type of distiller



THE RENOWN SEA WATER DISTILLER.

is the evaporator for supplying vapor to the condenser and distiller. The object aimed at in this apparatus is the combining of efficiency with very light weight, also handiness, easy cleaning, and compactness. The special feature of the heating coil is the application of tube elements with oval cross section. These elements are arranged one above the other, and the steam passing through each alternate element produces most effective heating surface. Moreover, the heating coils by their action are practically self-cleaning, and are so arranged in the water space as to prevent any priming whatever taking place. In the general designs of the evaporator the ordinary size of the heating coil is calculated to produce the terminal condensate of the heating steam at a temperature of about 212° Fah. It is often found convenient, however, to use this condensate for washing water, for cooking, or other culinary purposes, and as 212° Fah. would be much too high, a special arrangement has been introduced whereby a cooling effect is obtained in the evaporator itself, and the temperature considerably reduced. Only a small addition to the height of the apparatus is required in this construction, and practical experience and results have shown that the condensate, by this method, is cooled down to 104° Fah., being the best temperature for the purposes mentioned. The distribution of the cooled condensate through the ship is effected in the simplest manner by the pressure of the heating steam entering into the evaporator heating coils.—The Engineer, London.

HORSE-FLESH is largely eaten in Alsace. The retailers sell the choice cuts for about eight cents per pound and the ordinary for six cents. A large quantity is used in the manufacture of sausages. All horses, before and after being killed, are strictly examined.

THE HISTORY OF THE LATHE.

IT does not seem to have been noticed that a most important centenary, from an engineer's point of view, has been allowed to pass by without remark. We allude to that of the invention of the slide rest by Maudslay in 1794, an invention which it is safe to say is one of the most important and epoch-marking steps in the world's industrial history.

Practically, all we know on the subject is to be found in Nasmyth's "Essay on Tools," in the third edition of Buchanan's "Millwork," which appeared in 1841. This contains a drawing supplied by Francis, one of the sons of Joseph Braman, headed "Bramah's original slide tool, 1794." It should be explained that Maudslay was in Bramah's employ at that time. As might have been expected, the appliance shown in the drawing differs a good deal in appearance from the slide rests now in use, being composed of somewhat slender-looking superposed frames, which do not seem adapted for heavy cuts. This rest was stated to be in use at the date of the drawing. It would be interesting to know the subsequent fate of this important relic, which should have found its way into our national collection, which again should be in some place more readily accessible to engineers than is South Kensington.

The invention was not patented, and it has been suggested that Maudslay derived the idea from the construction of some boring mills, imported from Holland, at the Royal Arsenal, Woolwich, where he had served as a youth, and with which it is considered he must have been acquainted. However this may be, there can be no doubt of the importance of Maudslay's invention, and of his having been the man for the hour, although, indeed, the slide principle did not at first spread so rapidly as might have been expected.

A forerunner of the slide rest in the form of a guide for a hand turning tool is, as is pointed out by Herr Fischer in a recent number of the Zeitschrift des Vereines Deutscher Ingenieure, to be found in Hulot's memoir, "L'Art du Tourneur," in vol. xxiii of Description des Arts et Metier, 1775, in which, at page 375, we read: "Barre de Tour d'une nouvelle invention servant pour turner facilement des ouvrages parfaitment cylindriques." A guide bar of rectangular section fixed parallel to the axis of the lathe carries a slide adapted to be moved to and fro along its upper surface, and engaging by means of two projecting tongues with channels formed in the vertical side of the bar. Across the top of the slide is a groove for the tool, which is held down by a spring, and has an adjustable stop clamped on at the required point to limit its motion toward the work. The tool is to be moved to and fro by hand. This appears to have been the first application of the guide principle to the tools of turning lathes. Maudslay went considerably beyond this in producing a compound slide and in giving motion to the parts thereof by means of screws, operated at first by hand and afterward automatically. The first account Herr Fischer has been able to discover of a self-acting slide rest is in one of the 1823 volumes of the Jahrbuch des Wiener Polytechnischen Instituts. This contains a drawing clearly showing a slide rest, operated by a leading screw geared to the mandrel. Maudslay, had, however, some years before this arranged his slide rest for a self-acting motion, as appears from a plate dated 1815 in Dr. Rees' "Cyclopedia," in which is shown gearing for connecting the screw of the lower slide to the mandrel; change gearing with fixed centers, as well as the slotted radial arm or "banjo plate" arrangement, is described and

shown for cutting screws differing in pitch to the screw of the slide.

The lathe by Clement, described in the "Transactions" of the Society of Arts in 1828, shows some marked developments. It is a brake lathe with a rudimentary form of back gear, overhead countershaft and automatic variation of the speed of the mandrel for surfacing, by means of a pair of oppositely arranged conical rollers along which a driving belt is traversed; a self-acting movement can be imparted to the screw of the lower slide; the bed and slide faces are flat.

Fox, of Derby, about 1830, was using a rack and pinion arrangement for traversing the slide. In the German periodical referred to above attention is directed to full descriptions and drawings of lathes made by Fox for the Königliche Gewerbinstitut at Berlin, which are to be found in the Verhandlungen des Vereins zur Beförderung des Gewerbfleisses for 1831 and 1832. The reference may be of value to the future historian of the subject. One of these lathes, a face lathe, has the mandrel driven by a long train of gearing, any one of the shafts of which may carry the driving pulley. An endless chain working under the bed, and driven from the mandrel by spur and worm gear, is used for traversing the slide in the screw cutting lathe described as having been in use by Gallimores, of Sheffield, in "Manufactures in Metal," 1833. Two of the spur wheels were to be changed to vary the pitch of the screw cut, the mandrel is driven from a spindle at right angles to it carrying a stepped pulley and a bevel wheel adapted to engage either of the bevel wheels on the lathe spindle. Stepped pulleys grooved for catgut bands were in common use before that date.

Whitworth's first patent, in 1835, has the slide rest traversed by a leading screw fixed in the bed. It has back gear, open and crossed belt-reversing gear, overhead countershaft and change gearing with the "banjo plate."

The history of the steam engine as a locomotive, and for stationary and marine purposes, has been pretty fully dealt with in text books, and by correspondence and otherwise in the columns of the engineering press, but considering their immense importance, and the pre-eminent position that English engineers have taken up in their origination and development, it is very remarkable how little has been done with reference to the history of lathes and other machine tools. There must be among our readers many whose minds are stored with valuable and interesting reminiscences on this subject, which if made public would form most important material for the history of the subject.—The Engineer, London.

[FROM THE INDEPENDENT.]

THE INFLUENCE OF ANTISEPTICS ON THE PRACTICE OF SURGERY.

By SAMUEL LLOYD, M.D.

ADVANCE in science is never the result of pure chance or accident, but is the natural conclusion arrived at by some master mind that, fully equipped with a complete knowledge of the work already done by others, is able to carry the experiments to a successful termination. To have done this is not alone sufficient; the experimenter must present his results with such scientific accuracy that his report can withstand the attacks of all the other workers in the same line of investigation.

When the French chemist, Louis Pasteur, whose name has since become famous, collated the facts pertaining to the cause of fermentation and putrefaction, and when, between 1857 and 1865, he published his essays establishing beyond controversy that these processes were due to a micro-organism, he probably gave no thought to the vast possibilities of his discovery, beyond its advantage to the chemist and its explanation of phenomena which for so long had baffled the best endeavor of skilled investigators.

Up to the middle of the eighteenth century surgery could not be considered as one of the sciences. Practiced first by barbers, and then by barber surgeons, it was made up of methods that were handed down in secret from master to student. Wounds were treated with plasters and ointments, and surgical cleanliness was unknown. It was not known until after the time of John Hunter (1728–93), the youngest son of a Scotch farmer, to whom we owe the knowledge of the circulation of the blood in the arteries, that surgery had advanced beyond the point of "mere mechanical dexterity, with some knowledge of ointments and plasters."

Since this time Hunter's method of training in anatomy, pathology and surgery has been considered indispensable to the practitioner of surgery. It was still, however, far from being the exact science that its votaries hoped for but were unable to attain.

Since 1800 more progress has been made than in the preceding two thousand years; and yet the surgeon of this period "had little more knowledge than Hippocrates of the chief causes of danger after operations, such as suppuration, pyemia or lockjaw, and still groped wildly for means to avoid them." He had no clinical thermometer to determine the height of a fever, no hypodermic syringe, no knowledge of the importance of preventing loss of blood or of the means of doing it. He had no microscope, no ophthalmoscope, nor any of the instruments of precision that are so useful at the present day; above all, he was ignorant of anesthesia and of bacteriology, the two things that have made modern surgery possible.

In 1842 Dr. Morton, a dentist, administered ether for the first time in the Massachusetts General Hospital, while Dr. Warren performed a small operation; and from this date the study and practice of surgery received a fresh impetus.

Imbued with an enthusiasm equal to Pasteur's and working in the same methodical way, Joseph Lister, another Scotch surgeon, had been seeking for something that would explain the degenerative changes that were the constant menace of patients submitting to surgical operations and the scourge of surgical practice. He grasped the truths contained in Pasteur's publications and immediately adopted them in his surgical work.

While his method was hardly based upon scientific data, his clinical results were so much improved by the method that in 1869 he published it and became the father of antiseptic surgery.

Prior to this time, pus, matter as it is usually called, was the common result of operative interference and was even, under certain conditions, when less poisonous and less virulent than was sometimes the case, called "laudable." Laudable, indeed, the products of degeneration, of inflammation and of disease!

When Pasteur began to publish his papers Sir Spencer Wells and Mr. Jonathan Hutchinson "regarded the operation of ovariotomy as not much removed from manslaughter," says the latter in his address just delivered before the British Medical Association. No joints were opened when it was possible to avoid it, and the brain and spinal cord were a terra incognita to the operating surgeon, and when, by reason of accident, operations in these regions were necessary, they were undertaken with the greatest temerity and with the full expectation of a fatal result. The hospitals reeked with contagious diseases, erysipelas, septicemia and pyemia (blood poisoning) ran riot, and any hospital patient with an open wound was fortunate if he escaped simply with suppuration and without developing some more serious condition. A compound fracture, that is one where the bone has been pushed through the skin, making a wound in the soft parts directly communicating with the point of fracture of the bone, meant almost certain death. This was the condition of affairs in 1867.

Trained nurses were few, sanitary science was not understood, hospitals were overcrowded and were largely old buildings with wooden floors, whose cracks were filled with the accumulation of years of germ-laden dust.

The writer knows of a hospital which, twenty years later, was still employing the old methods of wound treatment; here one sponge frequently answered for every case in a ward of from twenty to thirty patients, and that sponge was often one that had been discarded after long service in the operating room. Fortunate, indeed, the patient without an external wound to absorb the poison; he might escape; but the germ-laden sponge carried infection to each of the open wounds in increasing virulence as the distance from the starting point of the surgeon on his rounds increased. With such surroundings the surgeon was indeed to be dreaded, and the sufferer whose only hope lay in the knife had good cause to fear the advent of the day of operation.

It is wonderful, as we look back at these times, how good the results were considering the conditions under which we labored. We are not surprised that the statistics of the surgeon who did his work in the country and in his patients' own homes were better than those of his city colleague, who had all the so-called conveniences of a great hospital and the advantage of seeing large numbers of cases.

Yet the country patient was not altogether safe. Everywhere the dreaded erysipelas, lockjaw and blood poisoning followed in the surgeon's footsteps; for he still carried his instruments in handsome cases lined with plush and the dust of years. The instruments themselves were also often disease bearers; wooden handles with their many cracks filled with hardened blood dropped their germs in the receptive soil of fresh wounds, there to grow and carry disaster with their growth.

This picture is not at all too dark, it is only the condition of affairs as they existed prior to 1867. In Messbaum's clinic in Munich, before the employment of antiseptic methods, eighty per cent. of all wounds were attacked by hospital gangrene. "Erysipelas was the order of the day to such an extent that its occurrence could almost have been looked upon as the normal course; not to sew up any wound of the scalp was a firm principle, and the suturing of any wound would have simply led to the retention of the discharges and the further encouragement of erysipelas."

In one year eleven out of seventeen patients who had had amputations performed died of blood poisoning, and compound fractures had to be amputated at once to avoid infections that would have been fatal within a few days.

In Volkmann's clinic at Halle the mortality following compound fractures was forty per cent. In America the usual mortality following amputation was about thirty-three per cent.

In the older text books on surgery, long tables of statistics appear in which the influence of the seasons, the temperature, sex, nationality or race are studied in relation to their influence upon the success of operations.

"We know to-day that the healing of a wound is entirely uninfluenced by these, as well as by other factors, formerly considered important, such as constitutional taint or individual predisposition. This change for the better is entirely due to our knowledge that, like fermentation and putrefaction, the infection of wounds is directly due to the importation and growth of minute organisms. Protect the wound from these organisms and it will heal kindly in a tuberculous, syphilitic or cancerous subject, in man or woman, in the young or old."

It is remarkable that the two greatest advances that have made modern surgery possible have been made by men who were not themselves surgeons. The first, Morton, the advocate and first administrator of ether, was a dentist of Boston; and the second, Pasteur, the discoverer of the influence of micro-organisms upon fermentation, was a French chemist.

Surgery, as we understand the term, only dates back about twenty-five years, for without these two discoveries its present achievements would have been impossible. The statistics of the past centuries are valueless, because they are laden with now almost unknown diseases. The hospital graduate of to-day has never seen a case of hospital gangrene, that scourge of the past; he seldom sees erysipelas in a surgical wound, and still less frequently pyemia and septicemia.

In reviewing the work of these years one man stands out pre-eminently above his colleagues as the one to whom the credit of this revolution is due. It did not take long for the surgical world to recognize the fact that the results obtained in Professor Lister's wards were distinctly better than those obtained in the other hospitals. Trial of the same methods naturally followed, and Glasgow became the Mecca for surgical workers the world over. It is to Pasteur primarily, but to Lister particularly, that the present scientific improvement of surgery is due. It matters not how far we may have traveled from the views first advocated by Sir Joseph Lister, it was his study and his adaptation of the facts that have made the present proud result a possibility. It is pleasant to remember that he is still living and receiving the tributes of a grateful profession. The English surgeons within a few days have presented him with a portrait of himself. He has been honored at home by being called successively from his professorship at Glasgow to a similar position in Edinburgh and in London; has received a baronetcy from his sovereign, and it has been suggested that an international memorial be erected to him, "as one of the greatest benefactors of humanity."

Listerism, or antiseptic surgery, was the first recognition of the influence of germs on disease, and it was perfectly natural that chemical substances capable of killing these germs should be employed in the method. This was on the principle that it was impossible to avoid germ infection. Germs swarmed in the air and on everything we touched, and so had to be killed before they came in contact with the wound. This method was very cumbersome. Large sprays of solutions of carbolic acid were kept playing over the surgeon, his assistant and the patient, not only throughout the operation, but during each of the subsequent dressings. But the tissues could not be kept soaking in chemical solutions without being affected deleteriously, and, although this method was a wonderful advance over former methods, there was still much to be desired. The principal disadvantages were the complexity of the system and the injurious effects upon the tissues of the chemical solutions. It was not until 1882 that Robert Koch, by studying various germs and isolating them, was able to demonstrate that the air was innocuous in itself and that none of the microbes could grow unless they were provided with the proper soil. Many investigators, turning their attention to this new science of bacteriology, soon demonstrated the germs that were of especial importance to the surgeon and studied their life history.

Once armed with an accurate knowledge of the germs causing different infectious diseases, and the soils necessary for their propagation, the surgeon was able to devise a means of avoiding in many cases the use of these deleterious substances. By killing the germs and taking care that none should be introduced into the soil or growth medium, which they required for their full development, a new system has been instituted. This is called aseptic surgery, and may be considered as an almost ideal method in comparison with those formerly in vogue. To have told the surgeon of the early years of the century that before its close we should treat wounds without sepsis, that instead of months being required to heal his incisions a few hours or days would suffice, would have led him to pronounce this statement a falsehood, an impossibility. This is, however, exactly what has happened. An amputation of the breast used to require four to five and even six months to heal; now only one dressing is required, and the wound is completely healed within a week. A laparotomy, which was considered a most dangerous procedure, shows only about two per cent. mortality, and the wound heals under a single dressing within a week or ten days. The statistics speak for themselves. The mortality of ovariotomy has fallen to less than ten per cent. In Professor Volkmann's clinic, at Munich, 318 major amputations, that is, amputations of a leg or arm, gave only 28 deaths, about nine per cent. Professor Dennis, of New York, has also reported 1,000 cases of compound fracture treated in several hospitals with a death rate from blood poisoning of only one-seventh of one per cent. This is in marked contrast to the report of the Obuchow Hospital, of St. Petersburg, in pre-Listerian days, where the death rate reached 68 per cent. in 106 cases of compound fracture, or of the Pennsylvania Hospital, from 1831 to 1851, where the death rate was 44 per cent. in 116 cases; or of the New York Hospital during the same period, when the mortality was 48 per cent. in 126 cases.

Hospital gangrene is now practically an unknown disease, and blood poisoning is more often the result of negligence on the part of the patient in not consulting the surgeon early enough than of negligence or ignorance on the part of the surgeon. The abdomen is now opened ruthlessly, and all the organs inclosed in this cavity are subject to the surgeon's care. Tumors have been successfully removed from the liver, the gall bladder has been excised, portions of the stomach taken away and new openings made into it, both through the abdominal wall and into the intestine. The spleen and kidney have been inspected and removed, and the intestine has been brought together and has reunited after the removal of several feet. Even the lung has been operated upon, and wounds of the pericardium (the covering of the heart) and of the heart itself have been treated, and the patient has recovered. Bones are now broken simply to correct deformity, and joints opened for exploratory purposes. The brain and spinal column are fertile fields for surgical treatment, and tumors have been excised, hemorrhage controlled, and the patients have lived useful and comfortable lives. Surgery is now a science; based upon the new theories of bacteriology, we know why failure was so common in the past, and how to avoid similar errors in the future. No longer a simple art, it takes years of special training in which the dead house, dissecting room, chemical laboratory and microscope all play important parts. Our hospitals offer a haven of security to diseased and injured mortals. The surgeon of to-day should not be a general practitioner; he has no time for anything outside of the advances in his own science, and the improvement of his own technic. Above all things he must be a trained bacteriologist, able to recognize the various germs that he finds, and to deal with them when their presence is discovered. If pus appears in a wound to-day, it is never laudable; it is a fault of technic for which the operator is responsible; some infected material has been used, and he at once repairs to his laboratory, examines the pus, and the different materials that have been employed, until the source of infection and the germ to which it is due have been demonstrated.

While the nineteenth century has seen so much progress in surgical procedures, it has but aroused the interest of multitudes of ardent investigators, and the results of their labor can only be still greater advances in the near future. With increased knowledge and

improvements in technic and precision, the closing years of the nineteenth and the opening of the twentieth century will again revolutionize surgical practice.

All the sciences included under the generic term of medicine are participating in this advance. Disease is yielding to improved knowledge and new methods. The profession is not laboring alone for the cure of disease, it is studying how to prevent, how to eradicate it; and it does not need a prophet to foretell that before long many of the most virulent diseases of the present day will be but memories of the past.

New York City.

THE "CAVE OF PHANTOMS."

EVERY year, to the great joy of idlers and the desolation of the inhabitants of the quarters invaded, spring brings us the noisy and monotonous fetes and fairs to which we have unfortunately been accustomed for a long time. Sometimes, however, an ingenious showman, thanks to some new attraction, succeeds in interesting us for an instant. Such is the case with Professor Hutschistkof, whose theater, installed for several months at the Russian Exposition, has been transferred to the fete of the tenth ward of Paris.

"The Country of Dreams" is the attractive title that is displayed upon the canvas of the little theater to which we are going to introduce our readers. A stage about 6 feet by 10, draped in black, but the back of which is brightly lighted, is provided with a chair and a table. This is the "Cave of Phantoms," where Professor Hutschistkof asks an obliging spectator to seat himself. Leaning upon the table, he patiently awaits the coming of the specter, which soon makes its appearance. Horrible to relate, the phantom approaches, recedes, and finally ends by embracing the subject! Filled with astonishment, the latter sees absolutely nothing, but excites the hilarity of the spectators by a dumfounded look. Before an impossibility so great, and very natural, since the poor man has no suspicion of the terrible vision, the specter disappears in order to give place to a more agreeable image—a young and pretty woman, who approaches the subject, throws him kisses and performs amusing acts, while her neighbor, with open eyes, vainly seeks to learn the reason of the laughter of the spectators. The fun is at its height, and the mystified subject, losing his head, makes his escape and goes to take his seat in the hall, in order to witness a repetition of his adventures by another person who is desirous to penetrate the secret of these mysterious apparitions. Let our readers spare themselves this trouble and simply cast their eyes upon FIG. 2.

As in what is called the "metempsychosis," but much improved, a plate of glass, A B, is placed in the center of the stage, perpendicular to the floor and forming an angle of 45° with the back of the stage. At C, in the side scene to the left, is placed the phantom, young woman, etc. Strongly illuminated, the image of the latter will form at C'. The phantom being capable, by some means or other (a glass placed in the other side scene, for example), of seeing the subject, can perform the most curious antics without the person seated and separated from it by the partitions, c c', being suspicious of what is going on around him. There would be considerable difficulty in rendering visible the image that is to form in an illuminated medium, were it not for the black ground of the stage, and an intense illumination, that renders it impossible to make out a difference between the virtual image and the person himself.

As there might be a danger of the mystified subject traversing the stage in his eagerness to escape, and of coming into collision with the transparent mirror, it would, perhaps, be prudent to cause the latter to slide in two horizontal grooves, which would permit of demonstrating the absence of trickery. The mystery that we have just described is very simple, and is analogous to the first specters of Robin, whose success at Paris was phenomenal. But the present arrangement, it must be admitted, is very well conceived and of a truly striking effect.—La Nature.

THE MAGNIFYING POWER OF TELESCOPES.

"So many questions are asked by intelligent readers about the magnifying power of telescopes, that it seems best to mention the important facts relating to this theme, so well known and so useful to the practical astronomer.

"For our present purpose all we need to notice about the telescope is its object glass and its eyepieces. The use of the object glass is primarily twofold, viz: to collect the parallel rays of light from a distant object that fall on its outer surface and to focus those rays in a small but well defined image at a distance from the object glass called its focal distance. The image of the celestial object thus formed will be bright in proportion to the amount of light which the object glass is able to gather and transmit to it. Object glasses of the same size may have different focal lengths and still be excellent in quality, but those having the greater focal length will form the greater focal image.

"A man much interested in all recent astronomy said to us the other day, 'If light is one of the things you want, why not use electric light and put abundance of it on the image, and then use still higher magnifying power, and so tell us more about the planets?' Most of our readers will readily understand that the astronomer is not favored in this way as the microscopist is. He has not the privilege of so illuminating the object whose image he is studying as may be done often in the use of the microscope. Generally the astronomer can use only the light that comes directly from the heavenly body, and he must plan to get as large a quantity of it as possible, and then cause that light to fall on the image at the focus that it may be greatly increased in size by the eyepiece and still be bright enough to be seen well. Astronomers are now trying curious devices in order to gather more light from the heavenly bodies so as to reach the end suggested above in a way that will be in keeping with common laws of physics.

"The use of the eyepiece is to magnify the image formed by the object glass and make rays of light from it sensibly parallel, as the normal eye can use such a beam of light for distinct vision. The different kinds of eyepieces in ordinary use accomplish this in different ways which are adapted to the kind of work the astronomer is trying to do. If he is trying to measure the distance between two stars, he may need a flat field, as it is called; then he will use an eyepiece like an ordinary hand magnifier, which he calls a positive eyepiece, because the image viewed by it is outside of itself. If the observer is making a careful study of the surface details of a planet, for example, he will then use another kind of eyepiece which is called negative, because the image from the objective is formed between the two lenses of the eyepiece that are usually separated from one another an inch or less. The positive eyepiece gives a flat field of view, but brings into it some color that does not belong to the object under study. This is the weak point in this kind of eyepiece, and because of this astronomers say it is not achromatic. The negative eyepiece is better in this regard, but it is not perfectly achromatic. So the observer must be on his guard in original observations that the slight imperfections of his instrument do not mislead him when he is trying to determine shades of color belonging to various celestial objects. . . .

"When we say the magnifying power of a telescope is 200, 500, or any other number, we do not mean that the given numbers represent comparative areas, as

FIG. 1.—THEATRICAL SCIENCE—"THE CAVE OF THE PHANTOMS."

the area of one circle with another, but we do mean the linear measure across the image as seen by the eye at the telescope compared to that of the visible object as seen by the unaided eye.

"Hence astronomers have come to use the word 'diameters' as a unit of measuring power instead of the use of the word 'times.' When they say a telescope magnifies 500 diameters, they mean that the diameter of the image is 500 times greater than that of the object as seen by the naked eye. If we were to compare the area of the image with that of the object in this particular case, we readily see that the former would be 250,000 times as great as the latter. In other words, the relation of linear diameters to times in area is always found by squaring the number representing the linear diameters of magnifying power. Thus a power of one thousand in diameters would be equivalent to one million of times in area. To the inexperienced this relation and the very large number it suggests seems untrue and wholly impossible, but nothing in astronomy is better established than this fact. . . .

"It is very rarely that we can use the high power of the telescope, because of the unsteadiness of the atmosphere. For it must be apparent to casual thought

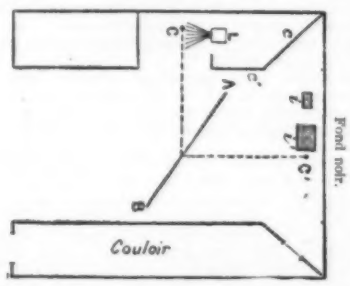


FIG. 2.—PLAN.

I, chair; i', table; c', image of the specter; L, oxyhydrogen lamp; A, B, transparent glass.

that when an observer is looking at a celestial body every tremor in the path of the light from that body through the atmosphere will be magnified in the same degree that the object itself is. So it is not an uncommon thing that the stars will dance in the telescope most tantalizingly while they look so beautiful, large and bright to the naked eye."—Prof. W. W. Payne, Popular Astronomy.

CITRIC AND TARTARIC ACIDS FROM CANE SUGAR.

By Dr. T. L. PHIPSON.

ALTHOUGH I have not finished my investigations on this subject, I hasten to reply to those chemists who have not succeeded in obtaining the results alluded to in my former notes. It is easy to point out where their error lies, but it will perhaps not be so easy to get them to acknowledge it. They have failed to obtain the products by oxidation, because they have not employed a sufficient quantity of permanganic acid. If they had jotted down the proportions requisite to supply the needful quantity of oxygen in order to convert cane sugar to citric acid, they would have found that it requires at least as much permanganate as the weight of sugar employed. No lime precipitates of organic acids are obtained with small quantities, and hence the errors of observation alluded to.

These gentlemen all assert that the precipitate on boiling consists of sulphate of lime, with no trace of organic acid, and that when nitric acid is used instead of sulphuric acid to acidify the sugar solution, no precipitate is obtained.

Here is an experiment made without sulphuric acid, in which nitric acid alone was used:

Equal weights of sugar, nitric acid and permanganate of potash are taken, and the mixed solution is left for twenty-four hours in the cold. The clear solution is neutralized by carbonate of lime, which occasions a copious precipitate. The clear liquid from this precipitate, when boiled, yields a further smaller precipitate. The first contains tartaric acid, and perhaps saccharic acid, which has the same composition as citric acid. It is soluble without effervescence in acetic acid, and therefore contains no oxalic acid nor carbonic acid. The second precipitate is citrate of lime.

If the clear liquid, instead of being neutralized by carbonate of lime, is almost neutralized by carbonate of potash, and stirred with a glass rod while still acid, bitartrate of potash is precipitated. The liquid filtered from the lime salts contains the whole of the manganese.—Chem. News.

ON GOLD SULPHIDE.

By A. DITTE.

THE action of a current of hydrogen sulphide upon a dilute solution of gold chloride varies according to circumstances. If the liquid is neutral, the first bubbles of the gas occasion a brown coloration, which deepens as the current passes, and when it is saturated it gives no deposit of a metallic sulphide. The solution is then deep brown, transparent, and passes through filters without losing any of its color. I then left it to itself, in a closed vessel, at the ordinary temperature; it is slowly modified.

The gold sulphide is transformed in the course of twenty-four hours, or of a longer time; the liquid is still dark, but it is discolorized on filtration, or if left alone, it slowly deposits gelatinous gold sulphide, which on agitation with water remains for a long time in suspension, forming a colored liquid. The addition of a few drops of hydrochloric acid to the dark solution which passes through the filters, or to that which holds the gelatinous precipitate in suspension, rapidly causes the deposition of gold sulphide in the form of a black powder, and the liquid becomes colorless. This condition is reached at once if a current of hydrogen sulphide is passed into an acid solution of gold chloride.

Gold sulphide may thus take very different aspects from the soluble matter produced in a neutral solution, or obtained, as by Schneider, on dialyzing a solution of gold cyanide in potassium cyanide saturated with hydrogen sulphide (Berichte, xxv, p. 2241) up to the dense black sulphide insoluble in water. This sulphide, if brought in contact with an alkaline sulphide, occasions various reactions.

If we gradually add sodium monosulphide to the black insoluble gold sulphide, it gradually dissolves, and an excess of alkaline sulphide gives an orange red solution having the odor peculiar to solutions of the alkaline persulphides.

This solution, if slowly evaporated in a vacuum, deposits aggregations of crystals formed by colorless transparent crystals radiating around a point. If well dried on porous porcelain, their composition may be represented by the formula $Au_2S,2Na_2S,20H_2O$. These crystals blacken on the surface under the action of organic substances. They are very soluble in water, forming a colorless liquid in which dilute acids give at once a precipitate of gold sulphide.

If the alkaline sulphide is only in very slight excess, we obtain an orange yellow liquid, which in a vacuum deposits fine needles of the double sulphide,

$$Au_2S.Na_2S,10H_2O,$$

and the mother liquor on further concentration yields a supersaturated solution, which sometimes coagulates in a mass, and sometimes deposits small prisms, short, deliquescent, not containing gold, very soluble in water, yielding a yellow liquid in which dilute acids give an abundant deposit of sulphur. They consist of hydrated bisulphide, $Na_2S_2,8H_2O$.

Thus, on contact with sodium monosulphide in excess, gold sulphide passes into the state of aurous sulphide, Au_2S, which combines with the alkaline sulphide to form double sulphides, soluble in water without decomposition, while the sulphur set at liberty forms sodium bisulphide.

It is otherwise if the gold sulphide is in excess. A certain quantity dissolves, and then the undissolved portion decreases in volume, changes its color, and after some days is converted into a dense, dull, greenish yellow powder, formed of very minute crystals adhering together and opaque. This substance contains no sulphur; it is pure gold crystallized in the moist way. The small proportion of alkaline sulphide placed in contact with the excess of gold sulphide forms at first a double sulphide and sodium bisulphide. The latter continues to remove sulphur from the gold sulphide, setting the metal at liberty until the alkaline persulphide is saturated with sulphur. Lastly, the double sulphide in contact with excess of gold sulphide is decomposed and changed into alkaline persulphide depositing aurous sulphide. If, when all the alkaline sulphide is saturated with sulphur, there still remains gold sulphide undecomposed, it undergoes no further modification, the alkaline persulphide having no action upon it.

The gold sulphide, in fact, does not appreciably dissolve in a solution of sodium sulphide saturated with sulphur. On the other hand, a solution of gold sulphide in an excess of alkaline monosulphide, with the addition of fragments of sulphur, gives rise to the formation of a deposit of black sulphide, which increases in proportion as the sulphur dissolves, and when the liquid is saturated it contains merely traces of gold. Finally, the gold liberated does not give rise to any inverse reaction, for gold leaf left for eighteen months in contact with a solution of sodium sulphide saturated with sulphur, at the ordinary temperature and in a sealed tube, is not affected by this liquid.

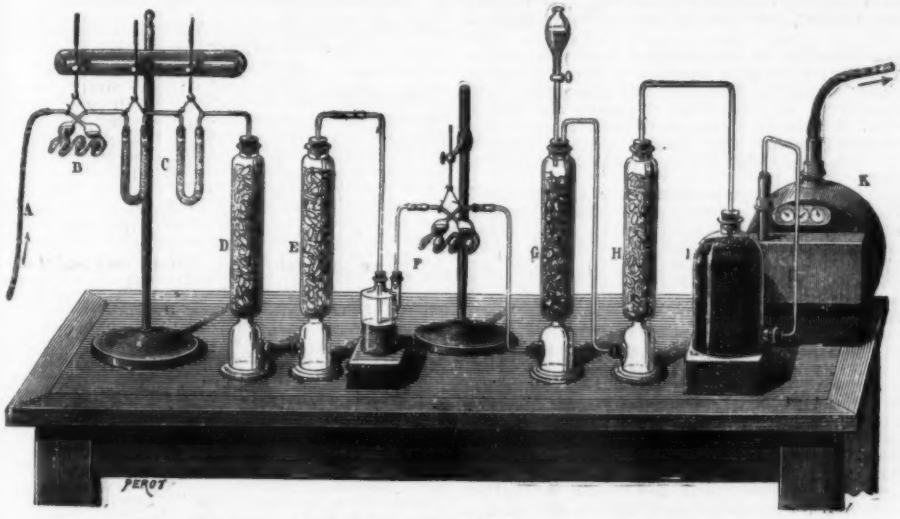
If for sodium sulphide we substitute that of potas-

sium, we observe analogous facts, but potassium sulphide—much more soluble in water than sodium sulphide—gives rise to double salts much more soluble in water than those formed with sodium, and more difficult to isolate in a state of purity. If we dissolve gold sulphide in a very slight excess of potassium sulphide, we most frequently obtain a residue of metallic gold on operating in the cold, or at 30° to 40°. The filtered liquid, if evaporated in a vacuum, becomes a thick red sirup, ultimately depositing crystals. The crystals may be freed from their mother liquor by depositing them upon a plate of very dry porcelain protected from moisture. The crystals are gold colored needles, very deliquescent, and very soluble in water, to which they give a yellow color. If exposed to light, they turn gray on the surface, and their composition may be represented by $Au_2S_4K_2S_2.12H_2O$. The mother liquor coagulates into a mass on concentration in vacuo, while no definite compound is separated.

Potassium monosulphide in contact with an excess of gold sulphide deprives it of sulphur and separates metallic gold, exactly as takes place with sodium sulphide. The potassium sulphide saturated with sulphur has, like the sodium compound, no action in the cold, either upon gold sulphide or upon metallic gold.—Comptes Rendus, cxx, p. 330; Chem. News.

ANALYSIS OF SEWAGE WATER.

AT Paris the impurity of the air of sewers is considerably diminished by the disappearance of privies and by the currents of water that carry along the fæcal matter and filth very rapidly and with a large proportion of liquid. The new process is designated by the name of "tout à l'égout." But, in the country, privies still exist, and one of our readers asks us how to proceed to the analysis of sewage water. We think it well to make known here the process employed at the municipal laboratory of Paris before the adoption of the "tout à l'égout." The apparatus figured herewith represents the arrangement adopted. In it, the air of the sewer is made to circulate through various glass vessels containing absorbing substances. Upon treating the solid or liquid substances contained in the absorption vessels, it is possible to estimate the proportion of the different gases or products, and by measuring, through the meter, the volume of air put



APPARATUS FOR THE ANALYSIS OF SEWER GASES.

A. Tube through which the gas arrives from the sewer. B. Liebig tube and U-shaped tube containing glass balls, the whole filled with arsenious acid dissolved in hydrochloric acid, and free, for absorbing sulphureted hydrogen. C. Two U-shaped tubes filled with fragments of humid glass with a few crystals of cyanide of potassium, for the cyanides and isocyanides. D. Column of chloride of calcium for absorbing the water. E. Column of solid alcoholic potassium mixed with glass for arresting the carbonic acid. F. Wolf bottle and Liebig tube filled with free permanganate of potash for the absorption of organic substances. G. Column of nitrous sulphuric acid for destroying the remainder of the products. H. Column of ferrous sulphate for absorbing the nitrous vapors in excess. I. Bottle filled with charcoal for the protection of the meter. K. Gas meter in communication with a suction pump.

in circulation, the proportion and quantity of the volatile or gaseous matters that contaminate it may be estimated. The apparatus consists of a table supporting a Liebig tube into which the vitiated air to be analyzed is sucked by an appropriate device. Thence it traverses two U-shaped tubes, and afterward two test glasses closed at both ends. It continues its way thus through other vessels of which our legend indicates the products.—La Nature.

DISTILLED EXTRACT OF WITCH HAZEL.

By W. D. HOEFFKEN, Ph.G., Ph.D.

DOES it possess the healing properties ascribed to it?

Under the title of "Aqua Hamamelidis" the National Formulary gives complete directions for the preparation of this article, as follows:

Hamamelidis, shoots and twigs	10 pounds.
Water	20 pints.
Alcohol	1¼ pints.

Place the hamamelidis in a still, add the water and alcohol and allow the mixture to macerate during twenty-four hours. Distill ten (10) pints by applying direct heat, or preferably, by means of steam.

By adhering to the above formula, a product containing 15 per cent. of 94 per cent. (or 14·10 per cent. of absolute) alcohol is obtained—presupposing that U. S. P. alcohol was employed—together with such substances as were dissolved from the leaves, etc., during the processes of maceration and distillation. But, unfortunately, all the investigations hitherto directed toward the discovery of any active principle possessing the wonderful healing properties ascribed to the extract of witch hazel have been barren of results, unless we except a small quantity of volatile oil to which the peculiar odor is due, and the alcohol that has been added as a perservative. The conclusion is therefore inevitable that the only active principle is this added alcohol.

Now, if alcohol is the only ingredient of merit present—which is actually the case—the therapeutic as well as the commercial value of witch hazel extract is of course dependent upon the amount of alcohol it contains. The writer has analyzed the following samples, which are of various makes:

No.	Percentage of Alcohol by Volume.	Reaction.	No.	Percentage of Alcohol by Volume.	Reaction.
1	8·76	Acid.	10	10·53	Acid.
2	10·25	Acid.	11	12.57	Acid.
3	8·82	Acid.	12	14·00	Acid.
4	8·83	Acid.	13	11·00	Acid.
5	8·32	Acid.	14	10·73	Acid.
6	8·25	Acid.	15	11·00	Acid.
7	8·76	Acid.	16	13·36	Acid.
8	8·00	Acid.	17	12·79	Acid.
9	10·51	Acid.			

In a few cases the extractive, which amounted to about 0·1 per cent., was determined.

The acid reaction is due to the presence of a small quantity of acetic acid.

In most cases the odor was bad, and more especially in those samples whose percentage of alcohol was below 10 per cent. Sample No. 11 proved of superior quality as far as appearance, odor and taste were concerned, though somewhat below the standard.

From the above table it will be seen how varied is the percentage of alcohol in the different samples, but one of them coming up to the requirements of the National Formulary.

Distilled extract of witch hazel is nothing more or less than a highly diluted alcohol, containing traces of valueless extractive matter and a small quantity of a volatile oil to which its peculiar and agreeable odor is due.—Bulletin of Pharmacy.

NOTES ON PRACTICAL PHARMACY.*

By WILLIAM WEBER, of Pittston, Pa.

THE drug journals generally give us something in each of their issues pertaining to practical pharmacy, and yet the field does not seem exhausted. For this paper I wish to offer a few suggestions on a number of topics, which are but rarely treated of, as far as I am aware.

I will begin with the fitting up of a drug store. Consulting the State news in the pharmaceutical papers, it is rather astonishing to see how many new drug stores are springing up all over the United States, notwithstanding the continued depression in business.

It goes without saying that it is quite a difficult matter to fit up a drug store to suit modern ideas. A great deal of care and good judgment is involved in the task.

Outside of the fixtures, it is the selection and, above all, the quality of stock which are to make up the reputation of the future druggist.

In the selection of the stock the druggist will be guided by past experience. He will be apt to place in his store the same line of goods which he has been in the habit of handling. But he may open in some other locality or section of the country, and he may not be called upon for some drug or other item for which he had made provision, either in a drawer, bottle, or other container; so it has happened to me, first starting in New York, then, shortly after, removing to Pittston; and I venture to say that no druggist in the United States has handled, or will ever handle, every article contained in the U. S. P. Drugs and preparations which are known and used in one part may not be known or used in another part of the country.

After deciding what to carry, the next and most important step is to make an outline of how that stock is best kept to preserve the qualities which it should possess. It is only of late years that the necessity of proper preservation has dawned upon the druggist; and it is only as yet now and then that a reference to this all-important subject is made in the pharmaceutical journals. How many drug stores are there yet in the land, where crude drugs—generally those only rarely used—are stored away in their original paper covers, cigar boxes, or any other containers which just happen to be at hand and seem suitable!

I cannot too highly impress upon the druggist the necessity of properly caring for his stock. How many druggists have not, from time to time, lost a customer by selling him something which was shopworn!

The U. S. P. 1880 contained but few references as to preservation of those items which it recognized; but the U. S. P. 1890 is much more complete in this respect. When we examine this point in the present U. S. P. more closely, we find that only the chemicals and a few other preparations have found due respect. In no instance, as far as I see, has anything been said upon the keeping of crude drugs—such as herbs, roots, etc.—excepting an animal substance, cantharides. The committee on revision must have had either of these two views: That the crude did not require any care at all in keeping or that the druggists knew all about it.

The latter I strongly question. Without some study of the subject, it is wellnigh impossible to name off-hand the best mode of keeping every item of the Pharmacopœia. We may take up a book on materia medica, and find the desired information here and there, but to gain anything like a complete list, we have to refer to a number of them. This I have done, and, with regard to the U. S. P. chemicals, I have gathered about the same data as there given. Prior to the publication of the last U. S. P. I had intended to publish a full list of the whole material gathered; but there is no necessity for this now, and therefore I treat in what follows only of the crude drugs, and of such other preparations in the case of which due reference as to keeping has not been made in the Pharmacopœia. The U. S. P. 1890 contains over 200 crude vegetable drugs, quite a respectable number.

A drug store could not well be imagined without rows of drawers. But open drawers are fit receptacles for only very few articles. I can recommend only the following to be kept in open drawers: rape, canary, hemp, and mixed birdseeds, whiting, sodium bicarbonate, powdered borax, powdered niter, powdered alum, powdered sulphur, logwood, gum arabic, resin, fuller's earth, flaxseed, Epsom salt, cream of tartar, brimstone, Rochelle salt (although slightly effervescent), shellac, pumice stone.

Of course, any of these substances may also be kept in bottles, and they are sometimes kept there; but, as the majority of them are good sellers, and quite a quantity must be kept on hand, bottles are more rarely used for them.

The largest salt mouth bottles made have a capacity of two gallons; but how awkward must their use be when compared with the rapidity with which we can weigh out a certain quantity of any of the above named substances from a drawer!

LAWS FOR KEEPING.

I will not enumerate every article the U. S. P. contains and say how it should be kept, but I will formulate two laws from the notes I have collected regarding preservation:

First. All drugs of vegetable origin must be kept in a dry place, as a great many of them attract moisture and therefore soon deteriorate. Such are burdock, squill, starch, cantharides, ground mustard, senna leaves, slippery elm bark, licorice root, quince seed, dextrin, and cocoa leaves.

Second. All those drugs whose activity depends on an ethereal oil or other odorous principle, must be protected from air and light. They are best kept in tin or in amber colored bottles. Perhaps the rule should be extended to all preparations containing an ethereal oil—such as the majority of the medicated waters, some of the tinctures, and spirits, etc. It would be interesting if experiments were made with some of these preparations exposed and not exposed to the light.

I refrain from giving a full list, as every druggist should be familiar with the constitution of the individual drugs. I will name only a few which require the utmost care: male fern, hops, vanilla (preferably in tinfoil), saffron, red pale rose leaves, rhubarb, and musk. Not a few of these also are quite bulky, and therefore easier to handle from a drawer than from a bottle: German and Roman chamomile, arnica flowers, sweetflag, valerian, ginger, Virginia snakeroot, and cinnamon bark.

In all such cases it is best to have the wooden drawers lined inside with tin, or, what serves me well, filled out with tin herb cans, such as are obtainable nowadays. A drawer of ordinary size will hold two of these comfortably. Such articles as althea, senna leaves, insect powder, celery seed, sweet flag, lump alum, ground mustard, and iron sulphate keep perfect in them. Open drawers for chemicals I would only allow in cases where the sales are rapid and the stock is replenished every one or two weeks.

It may not be amiss to mention here that most druggists keep a number of official vegetable drugs in one-ounce packages. A great number of these are put up now in such a way, and every live druggist can easily extend his line. They are also best kept in tin-lined drawers or in tin herb cans.

OTHER PREPARATIONS.

Having laid down two fundamental rules—to keep drugs of vegetable origin in a dry place, and those containing odoriferous principles protected from air or light—still a number of the pharmacopœial articles remain, which cannot be classed together. They are therefore best given separately, together with such additional remarks concerning keeping as the U. S. P. should have made:

Acidum Lacticum, in glass-stoppered bottles.
Acidum Oleicum, in tightly closed vessels and in cool place.
Adeps Benzoinatus, in cool place, same as adeps.
Adeps Lanae Hydrosus, tightly closed and cool, as the water evaporates, and the surface becomes darker.
Aether, protected from light.
Aether Aceticus, protected from light, as it easily turns sour, especially when exposed to the light.
Aqua Medicatae, those containing oil probably best kept in dark containers, and completely filled, and in not too cool a place.
Auri et Sodii Chloridum, protected from light.
Cerata, in a cool place.
Cetaceum, in a cool place; it turns yellow when kept for a prolonged period, and also becomes slightly rancid.
Charta Sinapis, in tin in a dry place, especially charta potassae nitrata.
Confectiones, in a cool and dry place.
Emplastra, in a cool place, in tin.
Extracta Solida, same as confections.

* From Merck's Market Report.

Fel Bovis Purificatum, the same.
Ferri Carbonas Saccharatus, exposed to sunlight as much as possible.
Ferri Lactas, the same.
Ferrum Reductum, in well-closed vessels.
Glycerinum, the same, because very hygroscopic.
Gossypium Depuratum, protected from dust.
Hydrargyri Chloridi Corrosivum, protected from light.
Hyoscinae Hydrobromas, the same.
Liquor Calcis, in well-closed vessels.
Liquor Ferri Chloridi, in glass-stoppered bottles, protected from light.
Massae, same as extracts.
Mel, Mel Despumatum, and Mel Rosae, in a cool place.
Mucilago Acaciae, the same.
Olea Aetherea, directions for keeping not uniform.
Pilulae, at an even temperature, not too warm.
Potassi Iodidum, protected from light.
Pulveros, directions for keeping not uniform.
Sapones, in a dry, not too warm, place.
Sodii Chloridum, in well-stoppered containers.
Sodii Sulphas, the same and cool.
Spiritus Aetheris, same as ether.
Spiritus Aetheris Compositus, the same.
Syrupus Ferri Iodidi, exposed to the light.
Tamarindus, same as confections.
Tincturae, at a uniform temperature.
Tinctura Digitalis, protected from light.
Tinctura Iodi, separated from other bottles.
Vina, same as tinctures.
Capsulae, in a dry, but not too warm, place.
Spongia, in an atmosphere not too damp and also not too dry; in the latter case they will lose weight; in the former, they easily acquire a foul odor, and become spotted.

I have stated in the above the best way of keeping most items of the Pharmacopoeia, and I hope my suggestions may be of occasional benefit to some of my fellow druggists.

The future druggist, having reached this point, must now select the suitable sizes of the various containers, and this is a matter which should receive more serious attention than it has in the past.

If we take a certain size of drawer and a one-quart salt-mouth bottle as standards, we should have lists to tell us how much, for instance, powdered potassium chlorate, charcoal, powdered ammonium chloride, compound licorice powder, etc., a quart salt-mouth bottle will hold. If such was the custom, we would not find so many mistakes regarding the sizes of bottles. As it is, the druggist is liable to find some of his bottles too small, others too large. I have actually seen a three-pint salt-mouth bottle used for red precipitate in a retail drug store of this city.

It had been my intention to determine the quantity possible to be held by drawer and bottle of every article I have in bottle and drawer, but as business is slow with me, this task would require too much time, since some items sell slowly. I can therefore only submit data on a few items.

A one-quart salt-mouth bottle will hold of:
Powdered ammonium chloride, 29 oz.
Powdered potassium chlorate, 3 lb.
Powdered potassium bicarbonate, 2 lb. 3 oz.
Wood charcoal, 1 to 1¼ oz.
Compound licorice powder, 1 lb. 6½ oz.

To obtain a correct result the substances must be finely comminuted; that is to say, the powder must be of uniform fineness throughout; the powder must not be pressed in, and the bottle should be filled only to the neck.

It seems to me it ought to be comparatively easy to determine the quantity of powdered drug held by a one-quart bottle when we know the fineness of powder used, for instance, aloes, cinnamon, licorice root, in powdered forms. In the case of crystallized substances and other coarse material, such as roots, mosses, etc., the result will not always be the same, since these vary considerably in size.

Still, the advantage to the druggist of a correct knowledge of this subject is quite apparent. He would know how much his drawers and bottles will hold. A great many stray packages result from this ignorance; the stock bottle may have been selected too small. The druggist has to buy, perhaps, a pound of an article, but his bottle does not hold the quantity bought, and the rest is laid away to deteriorate. Extensive trials or determinations would not be required at all if we knew the specific weight of all known drugs. But these we do not know to any considerable extent. The U. S. P. 1890 has nearly always given the specific gravity of the liquids, but not of the solids. I therefore append a few specific gravities which I have found in my readings: Resin of guaiac, 1·21; nitrobenzene, 1·16-1·2; arsenious acid, 3·738; balsam of tolu, 1·2; borax, 1·75; ferric chloride, 1·67; lycopodium, 1·062; antimony sulphide, 4·6-4·7; styrax, 1·09; talcum, 2·7; turpentine, 0·85-0·87; alum, 1·71; liquid tar, 1·06; ammonium bromide, 2·3; benzoic acid, 1·337; red oxide of mercury, 11·0; mercuric chloride, 5·3; aloes, 1·364.

Now, for another subject.

I have read a great many pharmaceutical papers, but never have I found in them any illusion to political economy.

I suppose it is not necessary for me to give a definition of what this science is; certain it is that but few druggists devote any time to its study, and yet how much useful knowledge for his business can be found in the same—such as his relation as a merchant to his fellow merchants! This is also the science which can give the druggist the necessary information regarding money, credit, banks, interest, profit, capital, and especially that very useful article, "circulating capital."

It is true that few persons engaging in any commercial enterprise have the necessary "circulating capital," else their business would prosper more and there would be fewer failures.

It is further indisputably true that a well stocked store has better chances of success in the business world than one where the means only allows of the scantiest supply. For that reason I would recommend to those having the means to make up from their one or two years' bills an aggregate alphabetical list of all the articles they have bought; for instance, January 1, Jones' Sarsaparilla, doz., 1-2; January 15, 3-2; January 21, 1-2, etc., adding the quantities at the end of the year. Of course, the dates need not be inserted at all; they are only given here as an illustration.

Thus, it becomes an easy matter to learn what quantity of each article one uses in a year's time; the knowledge of this is alone more than worth the trouble it entails in procuring. It may also serve as an incentive to us to try and sell more of certain articles, where we find, to our surprise, that our sales are below expectations.

Being now in possession of the list outlined above, I would advise those having the means to put in a quarterly or half yearly supply of the best sellers, making, of course, due allowance for any unforeseen change.

I will now present a few more lists, which, in my opinion, all druggists should have. First, a price list of all the articles he sells, with notations of the changes and additions in same as soon as a new bill is received, or at least weekly; second, a complete list of every article carried. It will then be easy to see, almost at a glance, what one is out of, provided close attention be paid to business; it partly saves the trouble of going over the whole stock every time when in need of fresh supplies; and it would not allow us to lose sight of any article.

A few words also as to putting up our own remedies. The pharmaceutical papers serve the druggist well with formulas for this purpose. There is no doubt that it pays well to put up liniments, cough sirups, sarsaparilla, and other remedies, and, in my opinion, it is perfectly legitimate for the druggist to do so, as he is compelled anyhow to carry similar preparations of other makes in stock. He should strive to familiarize them among his patrons, but in no case should he try to substitute his own preparation for some one else's. The customer generally has made up his mind, perhaps from reading an almanac or other paper thrown into his place of residence, to try a certain remedy, and if any substitute should fail to benefit him, a customer will surely be lost to you.

Contrary to the rule generally laid down—to begin with only a few remedies and extend the line gradually—it is equally as easy to put up a good variety at once. The pharmacist should be guided by the variety of patent medicines he sells; and label books, price lists of manufacturers of "non-secrets," and receipt books also furnish some ideas.

I would urge the druggist to put up the various remedies himself, and not to rely on the manufacturers of "non-secret" remedies to do it for him. The principal difficulty to the druggist seems to be the wrapper. But an elegant wrapper is not a thing of the utmost necessity. The outward appearance will necessarily vary with the class of people one has to deal with. I have, as a rule, only dealings with the lower classes here, and good quality of medicaments, clean bottles, good corks, and appropriate labels serve me satisfactorily.

During the first few years that I was at Pittston, I bought "non-secrets" with my name printed thereon. My name was, of course, to be a guaranty; but I feel certain that I was more than once served with goods through which I lost a customer. I still have on hand as a relic a 50 per cent. emulsion of castor oil, put up in small bottles, now seven years old, and separated how long I cannot tell, but no shaking can bring the parts together again.

Once I had three dozen bottles of cough sirup put up for me, with the formula on the label. I had occasion to open one of the bottles, when the quality seemed not to be what the label warranted. Just then I had an opportunity to try some of it in my own family; at the same time, I made some of the cough medicine myself strictly according to the formula. The taste of the latter (sirup of tar, wild cherry, etc.) was more pronounced, and the result far better. From my experience, therefore, I cannot recommend "non-secrets."

The druggist should also make his own tinctures, because they are the cheapest; tinctures made from fluid extracts are frequently not what they should be, since the menstrua for the two classes of preparations often differ.

Sometimes the stoppers of bottles containing resinous tinctures and also sirups become so wedged in that it is very difficult—sometimes impossible—to extricate them again. It would be well for the manufacturers of glassware to furnish such bottles with screw tops.

CLEANING BOTTLES.

Can the druggist make any use of old bottles? Certainly he can. If he put up many prescriptions, customers will from time to time call and wish to return medicine bottles. As it is not wise for the druggist to refuse buying them, what will he do with them? Throw them away? No. For years I have had washed all such bottles, and also all containers of fluid extracts and other bottles that can possibly be used again, with pearline. When any quantity of these has accumulated they are put into a wash boiler with the necessary water, and a quantity of pearline is thrown in. They are then set upon the stove for half a day, and afterward cleaned with a brush, after which they are as clean and good as when new.

Also the shelf bottles I have had washed out from time to time, as they become empty, with lukewarm water and pearline; let them soak for a few days, with occasional shaking, and then rinse them.

I like this practice, for the following reasons: Bottles containing powders, as a rule, gradually acquire a smoky appearance on the inside, and those containing liquids, such as tinctures or wines, are liable to have sediment deposited in them. Much of this can be averted if the druggist makes a larger quantity of the several tinctures, etc., than he immediately uses, and always fills his shelf bottles with tinctures that have been made for some time, and had ample time to become perfectly clear. Nothing looks worse than sediment in shelf bottles; they certainly do not add to the druggist's reputation. How bad does it look if a bottle with a sediment is taken up, and care has to be exercised not to mix the same with the clear liquid above! Therefore, only perfectly clear liquids should be in the shelf bottles.

IMPURE OILS.

With the oils we have another annoyance. They are sent to us in tins or other hidden receptacles. Generally the first quantities drawn are clear, but nearer to the bottom we usually find some impurities, as a rule the fault of the wholesaler. I have, therefore, made it a habit to pour some of the oil, as soon as I receive it, into a large graduate; if it is clear, well and good; if not, the filter is called into requisition.

CLEANING UTENSILS.

I wish here also to say a few words about the cleaning of mortars, graduates, and spatulas. Most druggists use very primitive means of cleaning these—cold water, sawdust, etc. But wiping out a greasy mortar with sawdust does not half clean it. The best method I know of is to use a dish pan with warm water, ordinary household soap, and a wash rag. We may then feel safe that the utensils are clean again. When one can clean his utensils properly, it is also a great convenience to have plenty of graduates to measure out tinctures and other liquids for the counter trade. The best sellers should be kept near the prescription counter, where the graduates can be easily used, and mostly unobserved. Measuring insures to every one the same quantity, and also saves the druggist from habitual loss by the old time guessing method.

Another vexed question to the druggist is the furnishing of bottles. How often is he met with the remarks: "I forgot the bottle," or, "I have loads of them at home; I can bring you down a bushel of them," etc. People have an idea that bottles do not cost anything; or they think the druggist's profits so enormous that a bottle thrown in does not matter. I am tired asking people if they want to pay for a bottle. If they call for 10 cents' worth of castor oil, they receive 2 ounces of the oil and a 2 oz. bottle; if for 10 cents' worth of spirit of niter or of essence of peppermint, a 6 dr. vial filled; if for oil of cloves, a ½ dr. vial is filled as an equivalent for 5 cents.

This practice saves me questions, and does not call the idea to the customer's mind that I make too much profit.

In this connection I would mention that I never use old corks on bottles brought by customers without corks. This is a reprehensible practice, and one that does not speak well for the cleanliness and hygienic knowledge of the druggist.

MILTONIAN TEACHING.

ON THE ATTAINMENT OF WISDOM AND LEARNING, OF KNOWLEDGE AND CULTURE.*

By R. H. THURSTON.

THE Blind Poet—learned in all the philosophy of the ancient literatures; wise in all that constitutes a sage; with a knowledge of all the arts and sciences and literatures of his own time, illustrating a culture characteristic of the gentleman and the scholar of his day—John Milton saw, more clearly than leaders of modern thought and life, the essentials of preparation for highest and truest ways of living. When he defines a "complete and generous enducation" as one which "fits a man to perform justly, skillfully and magnanimously all the offices, both private and public, of peace and war," he defines that "complete and perfect" scheme which is only now coming to be realized after more than two centuries have looked down upon his grave, and have missed his "harmonical and ingennous soul." His "philosophical college," as Cowley called the ideal transmitted from the master, was intended to be a "better and more liberal" institution than those of that time. His plan was to endeavor to insure "weaning from the useless babblements of the Aristotelian philosophy" of the educators of his day, and the establishment of the broader and more liberal education of the later technological schools, even including our "inspection tours" that take the student "in companies, with prudent and staid guides, into all quarters of the land." He would supplement the study of the languages and of pure science by the applied sciences and the arts of "fortification, architecture, enginery and navigation," and would call in "experts" in these vocations as "non-resident lecturers." Everywhere things were to be taught before words and actions were to take precedence of speech.

"The thought of any age determines the education of the age which is to succeed it;" and Bacon had, already, forty years earlier, struck the same note; his "Advancement of Learning" gave solid foundation to a scientific method that was to become the basis of the sciences and of the arts, as well—of all true education. Bacon inspired Comenius to the task of planning his "pansophia," the progenitor of the modern scientific encyclopedia; and his "pansophic university," or "universal college," "devoted to the advancement of the sciences," came near being established at the time of the outbreak of the rebellion against King Charles. Bacon and Comenius, and the Miltonian inspiration, were beneath the foundations of Sir William Petty's scheme of "a great technical college," "where all apprentices might learn the theory of their trades before being bound to their masters;" and of the greater plans of the Marquis of Worcester—of the same generation with these other grand minds—that of a technical university of all the arts and of all the sciences and of all current literatures. But even these schemes of the seventeenth century had their most perfect prototype in the Alexandrian school, a true "university" two thousand years earlier—the first, I am not sure but that I might even say the last, real, Miltonian, university.

That the "complete and perfect education" should involve the study, and the promotion, of all the literatures, of all the sciences, of all the arts of the time, has nevertheless been the unanimous thought of all great minds. Says Emerson: "Man is made up of potencies;" "We have keys to all doors;" "The world is all gates, all opportunities, strings of tension waiting to be struck." Then, I would say, give the child introduction to all worlds, keys to every lock, opportunity to enrich himself by every latent talent. The same modern sage says: "By his machines, man can dive and remain under water like a shark; can fly like a hawk in the air; can see the atoms like a gnat; can see the system of the universe, like Uriel the angel of the sun; can carry whatever loads a ton of

* An address delivered at Pratt Institute, Brooklyn, December 11, 1894.

coal can lift; can knock down cities with his fist of gunpowder; can recover the history of his race by the medal which the deluge, and every creature, civil or savage, or brute, has involuntarily dropped of its existence, and divine the future possibility of the planet and its inhabitants by his perception of laws of nature." Show, then, I urge, to boy and to girl, alike, and to all boys and all girls, alike, how to prepare themselves for such various work and accomplishment.

Every man having to do with intelligent workers agrees with the New England teacher that "a cultivated laborer is worth many untaught laborers," that "a scientific engineer, with instruments and steam, is worth many hundred men, many thousands; that Archimedes or Napoleon is worth, for labor, a thousand thousands." We should then give the people wisdom, as well as knowledge, learning, as well as culture.

The great philosopher, believing that "a new degree of intellectual power is cheap at any price," especially praises New England "because it is the country in the world where is the freest expenditure for education;" that in which was first effected that greatest of revolutions which decided that "the poor man whom the law does not allow to take an ear of corn when starving, nor a pair of shoes for his freezing feet, is allowed to put his hand in the pocket of the rich, and say, 'you shall educate me, not as you will, but as I will, not in the elements, but, by further provision, in the languages, in sciences, in the useful and in the elegant arts.'"

The great philosopher is a good witness; for he is Greek Plato, with the wisdom of the intervening two thousand years added, and he recognizes, not only all the requirements of the youthful race of Greeks, but also all that those intermediate thousands of years have given of higher and more imperative demand.

If education is to be that training which shall fit men and women, in youth for the "sequel of their lives," as Paley has asserted, it must give development, strength, symmetry, useful and fruitful beauty, to body and mind and soul: With the ancient Greek philosophers, athletic sports and games, and logical disputation; with Milton, horsemanship and swordsmanship, and arts and letters and mythology; with the modern sage, modern sports and games united with modern arts, later literatures, current scientific research. With all, bodily exercises, gymnastic, literary and scientific studies, the applied sciences and the occupation of the soul and of the affections in practical ways and resultful directions, constitute the components of the ideal, the complete and perfect, education. This is that ideal type which we may be sure will prove "most effective in broadening our sympathies and rendering us helpful to our fellows."

In planning for such a result, however, we can easily see that the last, in some sense, must come first. We must insure the ability to do, first and surest of all, if we would be certain that our sympathies shall lead us to make ourselves most helpful to our fellow men. We must make ourselves competent to care for ourselves, if we would care for others.

The training of youth has, thus, for its first duty their preparation for self-helpful usefulness, for the acquiring of first a competence, then of a surplus, either of working power or of capital—if they are to be helpful in highest degree, of both.

Whatever the method of education adopted, however, while making the first and main purpose that of giving the body and brain working efficiency, it should always be remembered that health and strength of body and brain go together, and high commercial value can only come when the physical part is cultivated most effectively. Whatever the method of education, also, physical health, strength—and beauty as well—mental power and acuteness, moral strength and real goodness—the qualities of the true gentleman—must all be brought to highest degree of perfection, even to make a successful man in the everyday world. The organizer of a continent-binding railway and the grocer fixed upon a corner of the street must, alike, for fullest success, be given a maximum of wisdom and learning, of knowledge and culture.

And all these may be conveyed to or developed in the youth by a master of this type, whatever the course of study and training found necessary in the endeavor to adapt the work to the circumstances of the man. Fortunately, whatever the character of the training especially called for, something can usually be done in all essential departments of the complete education. Even in the trade schools manual training gives physical exercise and the control of the members of the body; the most elementary studies give something of knowledge and real learning, and confer ample power of acquiring wisdom; while the acquisition of a knowledge of the elements of the English language and literature at least opens the doors, through the help of the translators, into all the culture of the ancient classics, as well as into the even richer culture of our own tongue.

Gymnastics constituted a fundamental component of the Greek training, and "manual training," as we have come to call it, is our modern substitute, where, as is usual with us, we deal with those who must earn their daily bread—a class left out of the educational scheme, entirely, by the ancients. That union of science and practice in the arts, which characterizes the modern, newer education, is often the basis of as high intellectual as of useful practical development.

The example of Archimedes, constructing his own laboratory apparatus, has been a thousand times repeated by the famous men of later times; and Galileo Galilei making his own telescope; Torricelli contriving a barometer; Michael Angelo painting wonderful pictures and carving marvelous statues, and, at the same time, ready, at the command of his sovereign, to build impregnable fortifications; Franklin contriving the lightning rod; Watt and Fulton concentrating scientific learning, practical knowledge of engineering and the intuitive wisdom of genius, in the production of the steam engine and the steamboat; Sir Humphry Davy making the principal apparatus of the modern laboratory; Babbage discussing the political economy of manufactures, and inventing his almost miraculous calculating engine; Lord Rosse planning his own great nebula-resolving telescope; Wheatstone and Morse, with their telegraphs; Bell inventing the even more astounding telephone; the self-instructed Stephenson and his locomotive; all our modern electrical engineering and the contemporary engineer, most of all—all these illustrate the union of science and art, of learning and practical knowledge; that union which, directed by highest wisdom, results in the production of those innumerable miracles which so largely make up contemporary life.

For even the wealthy, Locke and Rousseau recommended manual training, partly as a wise substitute for the "useless and dangerous pastimes of fashion" and partly as a provision against possible adversity; and the monarchs of Europe are often given instruction in the trades almost as complete as that of Peter the Great, of Russia.

In this, the Greeks were, as always, wise; and Solon even made it a law that parents neglecting to see that their children learned some regular and standard trade should have no claim upon them, in old age, for support. The moral results even of such training as comes to the youth with the drudgery of apprenticeship, or the brighter life of the trade school pupil, are, and should be, important. He is taught patience, prudence, right thinking, conscientious work, honest effort and good habits generally. Science means absolute honesty and truthfulness, whatever the outcome; the practice of the mechanician compels similar integrity of act, if highest results are to be achieved, a good record established and a reputation made.

Discipline, the acquirement of the habit of prompt and exact obedience, is another moral outcome of correct training of this sort, which has inestimable value to the fortunate pupil. Wisdom, justice, goodness, may be taken as natural sequences of moral product in education of the right kind, even though it be in kindergarten or in manual training, or in the trade school.

Instruction, in whatever direction, is a means of education; but the instruction of the class room is by no means the whole of education. Instruction, in the sense of simply imparting knowledge, is quite a different thing from completely educating the faculties and training the body or the mental or the moral side of humanity. It is a part, but not even the principal part, of education. It is far from being the whole of education, as so often apparently assumed by educators themselves. True and complete education involves instruction in all the literatures, all the sciences, all the arts, and the promotion of physical growth in health and strength, and of moral development as well.

The natural and proper order of education begins, obviously, with that which teaches, first, the elements of all instruction, rapidly and completely, and in proper sequence, and, as maturity of age and intellect permits, the fundamental principles of those divisions which all should study, whatever the intended or expected future life of the individual.

"Any real education must be such as best prepares the man, and the woman no less, for successfully striving for all that either may fairly and rightfully hope to gain from the world and to find in life. It must cultivate the mental powers, give physical strength and endurance, supply wisdom and knowledge for application in all the fields of life work, offer special instruction and training where needed for prosecution of those branches of industrial occupation which demand either higher education in the sciences or special knowledge of processes and methods of work such as cannot be subsequently obtained by the youth leaving his teachers behind him and going out into the world to take up his tasks, whether in the forum, on the bench, at bar, in the pulpit, by the sick bed, or at the table of the operating surgeon; whether he goes into art or architecture, engineering or school teaching, building steam engines or cotton machinery, railways or canals, working at the loom or at the blacksmith's fire."

"The aim of the framers of any system should be to prepare for the development of all the industries, the creation of intelligence, the encouragement of good morals, and a righteous distribution of moral, material and intellectual good to all citizens—as far as nature permits, in equal degree through equal opportunity. The greatest practical diversification of industries, the widest distribution of wealth and knowledge, all and equally, should be the purpose of the builders of the nation's noblest structure. It is this reconstruction of the ideas of Plato and of Milton and of all great minds since the time of Aristotle which we now see rapidly taking form around us. The real university is coming into being; the teaching of teachers, as well as the training of pupils for the real work of life, is one of the illustrations of the extent and completeness with which the old idea has been incorporated into the new and still more perfect form in this later time."

"This new education, which is yet the old, is simply that advance in the application of those never denied, long admitted principles of public policy which has come to be demanded as a consequence of the progress of the age in invention, in the arts, and in all our systems of industry. Reading, writing, and arithmetic were once the all-sufficient education of every class engaged in industrial pursuits. To-day a college education is insufficient to meet the demands of some of the professions and special schools are established in every country and in almost every city. A few years ago there were but three professions and but three kinds of professional school. To-day there are many, both of the professions and of the schools. The old education was mainly gymnastic; the modern is both gymnastic and immediately useful in the vocations of daily life. The old university was home for those who were called by Isaak Walton 'eloisteral men of great learning;' the university of to-day is a workshop of all the arts, sciences and literatures. It is the product of a growth, not of a new planting, however, and we may reasonably hope for splendid fruitage, with indefinite, future improvement with the coming years."

"But science and technical studies will never and ought never displace the older departments of education. As the one is absolutely needed for the material welfare of the country, the other is no less essential to intellectual prosperity, and to the cultivation of a scholarly spirit and to the growth of the æsthetic side of life, of all that makes the possession of wealth really desirable."

"When the new system shall have become fully developed, it may be hoped and fully expected that it will be common, if not customary, among those who pursue science and study the professions, if engaged in construction, to secure the broad and liberal culture of the older schools before entering upon their purely professional studies. Their line of work should lead into and through the college, and on into the professional schools. Knowledge, discipline, training in all the humanities, may and should precede the final special preparation for the work chosen by the citizen as the means of doing most for the world and of acquiring fortune."*

The "new education," as adapted to the needs of the people generally, must, however, be arranged on the assumption that the period of life which is assigned to the preparation of the youth for future years of fruitful work must necessarily be comparatively short, and must usually terminate at sixteen or eighteen, and almost always on the attainment of his majority. In order to meet this requirement successfully, and yet to adapt the system to the needs of all classes whose interests are to be subserved, it is evident that the studies must, if practicable, be so grouped that each class shall be given those subjects which are common to the demands, at a common age, of all, and that the special and restricted requirements of numbers lessening as age is gained must be deferred, where possible, to the later years of the period covered by the whole scheme of public education. Thus, the primary schools naturally give of the most elementary subjects, only such as are common to the whole body of pupils, whatever their plans and prospects. The secondary schools should include in their curricula that instruction, in literature, science, and the arts, which is needed by those who must soon leave school, to work for themselves, and to the exclusion, if necessary, of those studies which are introductory to the advanced work of the man of leisure or the proposed candidate for one of the professions. As one of the best, though anonymous writers on this phase of the subject has put it:

"If 'classics' were delayed, for example, entirely to the more advanced school stage, the pupils would be taught together in the earlier years all those subjects which are of common importance to all, whatever their distinction in life." Then "if fewer persons were taught the elements of 'classics,' more would learn their use; if fewer learned the letter, more would imbibe the spirit. In this way, those who should still learn 'classics' would have the immense advantage of not having sacrificed, for their sake, things much more important; while those who should not, might well congratulate themselves on having acquired much valuable knowledge, and excellent mental training to boot, in exchange for a pittance of Latin and Greek, soon forgotten, and to them, almost useless while remembered. Nor is this plan the less worthy of consideration because it would powerfully tend to renew the prestige of 'classical' learning, at the same time that it would systematize the current opinion of a great class of intelligent citizens, who 'feel the necessity of a limitation.'"

Nevertheless, says the same writer: "If Latin and Greek be unprofitable to the great majority of students, it does not therefore follow, as some eager innovators would have it, that Homer and Virgil are to be banished from the public schools altogether, and steam engines and calculating machines substituted in their place. Let it not be! Let us not snap cruelly the golden chain that has so long and so pleasantly bound us to the past! Let us not unbridge the mystic gulf of centuries profanely! Let Virgil and Homer live, as good things, and among the best, for those who have time and capacity to 'drink deeply of the Pierian spring!' But let them not be wasted in mere rudiments and disciplinarian externals. Let the study of the ancient literatures be reserved for the higher classes in the school, for those whose minds have grown mature, and become capable of comprehending the objects which it contemplates; and the 'classics' will again assume their rank and dignity, now so seriously compromised by their indiscriminate application."

As the Edinburgh Review once asserted: "The ancient languages are now taught, at once, too extensively and not intensively enough." There is, I fear, too much reason to-day for the observation of Sir Walter Scott in "Old Mortality:" "The flowers of classic genius with which the teacher's solitary fancy is most gratified have been rendered degraded, in his imagination, by their connection with tears, with errors, and with punishments; so the Eclogues of Virgil, and the Odes of Horace, are each inseparably allied in association with the sullen figure and monotonous recitation of some blubbering schoolboy."

And Lamartine, in the same strain, in his Pilgrimage to the Holy Land, makes a similar lament. He says, "Each wave brings me nearer to Greece. I touch its soil; its appearance affects me profoundly, much less, however, than it could have done, if all these recollections were not accompanied by the consciousness that instruction was forced on me, to satiety and disgust, before I could comprehend it. Greece is to me like a book of which the beauties are tarnished, because I was compelled to read it before I could understand it. I prefer a tree, a spring under the rock, an oleander on the banks of a river, or the fallen arch of a bridge covered with convolvulus, to the monuments of one of these classic kingdoms, which recall nothing to my mind but the ennui they gave me in my childhood."

If this is the feeling of men of genius like these, what must be the mental attitude toward all higher literatures, of whatever language, on the part of lesser minds upon which they have been forced before the recipient was ready to appreciate and easily assimilate them!

So, we should say, it would seem: First, the "three r's;" next the essentials of practical and profitable prosecution of life's work, then, and in the highest degree possible, the acquisition of science, literature, and art—of the arts, as well—in furtherance of the aims of those who can and will attempt the cultivation of the characteristic elements of higher learning, and of "complete and generous" culture. By this simple and adequate principle of adjustment of educational work to all the conditions of the educational problem, will, in highest degree, every demand be satisfied, and most be accomplished for all. Thus and thus only, if

* Technical Education in the United States: R. H. Thurston. Trans. A. S. M. E., 1893; vol. xiv.

we may trust the strongest minds which have yet discussed this problem, may wisdom as well as knowledge, learning as well as culture, be most extensively and perfectly and permanently diffused.

If I may be allowed to express this idea in words already addressed to another and a different audience, I would state the case thus:

"The ideal education would be such as should fit the citizen for the successful pursuit of every desirable object in life, while enabling him to secure the capital needed for its complete enjoyment. It would begin with the primary instruction demanded as preparatory to the studies of its later periods. Then this primary education would be followed by so much of secondary education, in the sense in which that term is now generally used, as should give the youth the essential elements of a truly liberal education, such as should prepare him to continually advance into the unlimited fields of human knowledge; to gain, from day to day throughout all his later life, more knowledge and higher learning in all divisions of science, literature and art; to enter upon the philosophical study of history, the comprehension of comparative philology, the development of the literatures, the seductive and wonderful problems of mathematics, the no less wonderful principles and strangely beautiful phenomena of the physical sciences, the still more marvelous laws and operations of nature as illustrated in the living creation, and, more than all, to obtain some comprehension of the moral and the intellectual, sufficient, perhaps, to gain a glimpse of that great spiritual world of which the grandest minds and loftiest imaginations that the human race has yet produced have never been able to fully grasp more than the most infinitesimal proportion. A truly liberal education, and by this I mean vastly more than a strictly classical education, fits man to walk with his creator in every field, spiritual, intellectual, physical, which the creature's faculties are given him to explore."

The education of the youth, becoming mature in mind and body, must be made usually special. He has been given the means and has been shown the way by which to enter into his wonderful heritage of the universe. Now, because he cannot grasp all and because he must prepare himself for such complete knowledge of a vocation and of all which is demanded for its successful prosecution, and because he may undertake but a very small part of the work of the world, and that in a very restricted field, he must become a specialist, and must in this work confine his time, thought and labor to the acquirement of a profession or of a vocation. This must be the final period of his education; for, after entering upon his chosen life's work, he cannot usually expect to find opportunity to continue his education as an occupation. He must then buckle himself to the task and take only such rare and short intervals for intellectual pursuits as may be given him in the hours of rest and leisure.*

The "type of education" is practically necessarily and very properly determined by the controlling considerations of life and work, and by the necessity on the part of the people as a rule of giving their time and expending their thought for the preparation demanded, not by their physical, moral or mental development, not by their ambition to acquire knowledge simply, or learning, or wisdom, or culture, but by the necessity of insuring first of all and above all safe entrance into life's work and successful protection of themselves and of those dependent upon them for sustenance, comfort and opportunity. The insurance of the privilege of living at all is the most imperative, if not the highest, duty of the average individual in modern society. This determines a choice of education which is by no means such often as would be otherwise voluntarily selected, and compels the adoption of a scheme of education by the State, which is definite in form as in extent and range. This education is not primarily planned to promote the development of character or the attainment of learning or the improvement of the physique.

The question to be asked by the educator is not precisely, therefore, "What type of education is most effective in broadening our sympathies and rendering us most helpful to our fellow men?" It is rather, To what extent may we utilize a form and extent of instruction already prescribed by our necessities in the promotion of the highest ends of the ideal education and training? On carefully studying the case we shall, perhaps, find that utilitarian instruction and the humanities are not so far separated after all. Possibly it may be found that all ends may be served by placing duty first.

In every age and phase of life we contend for, first, necessities, as we regard them; second, comforts, as we rate them, and, finally, luxuries, as we define them—each judged by an ever-changing standard which passes, continually, one after another of the items of the upper into the lower classes, as civilization and improved methods of production and of living mark new stages of an as constantly advancing civilization. Thus, in education, the primary instruction of the schools, with its "three r's" and its elements of mere beginnings, constitutes one of the necessities of all classes alike. The secondary education, which offers some knowledge of literature and of language, a little elementary science, and the various branches of the "common school" curriculum, may be classed as among the comforts of modern intellectual life; and the higher schools and colleges, and the professional schools, offer the more fortunate section of the people the luxuries of education. The plan of instruction of the mass of the people must, to be efficient, present to all classes the "necessities" of this complex course; it must follow with its presentation of "comforts" to such as may be able to defer their struggle with life long enough to gather up what is offered them; and, finally, it should give those who are so fortunate as to be able to take ample time, and to expend the necessary capital in self-support for the longest period desirable, all the "luxuries" of higher education and of technical training. May not thus, at the same time, a way be opened for the ultimate attainment of all that is desirable, if not for actually at once conferring it upon all classes?

The number of those who are able to spare the time and meet the expense of an ideal, complete, and perfect education is so small, in this country, that our main attention must be given to the less fortunate, who must content themselves with such studies mainly as afford the means of gaining a livelihood. Such must forego the acquirement of the ancient languages: but every one may, in hours and days of occasional leisure, avail himself of translations, and may find the thought of every great classical writer, ancient or modern, in English.

May they not thus acquire the whole meat of even the classical nut? They must leave to others the pleasures of roving at will among the modern foreign literatures; but they may still meet the soul of every great German or French, or Spanish or Italian, or even Russian author, in the same way.

I know a man who, when an apprentice, saved his pittance by dressing in gunny cloth, and bought candles for use when fire light was unavailable, and made himself familiar with the whole range of history, literature, and sciences, in the hours between the close of the day's work and midnight. He is to-day wealthy, a leader in society—not, however, in "fashionable" society—and is the envy of crowds of men who started with the luxuries of life free to them in all departments. A more interesting, entertaining, and instructive conversationalist I never met. Yet he has become wise through thought only, learned through use of the English language solely, has a wider knowledge of men and things, present and past, than nineteen out of twenty college men; and his wisdom, learning, thought, and dignified mental attitude have resulted in a culture that is recognized as remarkable by all who meet him.

Thus, after all, the common school education, with its "three r's" as a starting point, leading up into the manual training and trade school, and, sometimes, on into the professional school of engineering—even though giving no word of classical language or literature—an education in English and in the sciences, and in useful applications of physical, intellectual, and moral powers, while giving the means of insuring comparative safety against the ills of life, and providing all its comforts and many of its luxuries, is not, after all, altogether valueless for culture; and the broadening of sympathies, and the helpfulness which every man desires to be able to exhibit toward his fellows, may find in such training their firmest and surest foundation.

If we may not read Plato, we may read Emerson, the Plato of two thousand years ago plus all the added learning and culture of the interval. If we may not study Cæsar's Commentaries, we may read of the great captains of later times, Washington and Wellington, and Napoleon and Grant, greater than Alexander and than Cæsar by the accumulated experience, and thought, and genius, of the evolution of centuries. With the Bible, and Milton, and Shakespeare, the impecunious youth of to-day may at least become familiar, and, thus taught, he will gain wisdom and knowledge, and learning and culture, in far higher degree than from a whole library of other and older authors, of whatever race. What ancient or foreign philosophers were wiser than are our own? What poets of Greek, or Roman, or Sanskrit, or Arabic literature, or what songsters in modern foreign tongue, have sung as sweetly, thought as purely, and with as superlative richness of idea and of imagination, as Wordsworth and Whittier, Browning and Bryant, George Herbert and Thomas Hood, as Holmes and Longfellow, and Tennyson—prince of all poets, ancient or modern? Where, in all the world and in all the centuries, is a lovelier work, in fiction, even considered as a literary production, simply, than Lorna Doone? Where are brighter pictures of the older life than Hypatia and Ben Hur? Where are to be found, outside the limits which confine our unwealthy boys and girls, and youth, and men and women, can be found better thought and higher stimulus than, within their reach, in the works of Addison and of Irving, models of graceful thought and beautiful diction; of Dickens and Thackeray, limners of human life, thought, character, and act, such as the world never yet saw elsewhere? The wealth of the world, in science, in literatures and in the arts, in every department of human thought, is found within the treasury of the English language, and is accessible to the poorest as well as the wealthiest citizen. Moral, intellectual, and physical training, and all learning and all culture, are at the hand of every one who chooses to seek and to seize them; even though the ancient languages and the modern literatures, in the original tongues, are inaccessible.

I would therefore, finally, say that the type of education and training "most effective in broadening sympathies, and rendering the individual most helpful" to his fellows, is that which gives ability to be helpful; and I would trust to opportunity, to develop all latent sympathies. Given the power of effectively aiding others, the sympathies will be found always present; given the means of utilizing generous impulses, they will be found always fruitfully active.

Teach habits of physical and mental activity, and a healthy body and mind will be prolific of wholesome and noble thought; cultivate skill in fruitful industries, and the inclination to employ that skill in helpful ways will not be lacking; feed the soul with the harvests of thought of all ages, with the gleanings of the wisdom of the centuries—in whatever language, however given verbal expression—and all sympathies, latent or active, will find their destined place and work. Breed "the soul of the sage in the body of the athlete," and give the perfected soul, within its perfected body, ability to do for itself and others what life may demand of it, and trust that what may be done most effectively for the world will be done best by this perfected humanity, through the exercise of broadest sympathies and most efficient powers of aiding fellow men.

It is thus that the Miltonian training, reinforced by Miltonian learning, perfected by Miltonian culture, doing most for the humblest, much for the highest, whether ranked by place or by mind, giving health to the body, skill to eye and hand, stimulus to the intellect, and greatness to the soul, will, always and everywhere, "most effectively broaden the sympathies and render the individual most helpful to his fellow men."

* "The Nation's Great Problem;" Rose Polytechnic Inst. commencement address, 1895. R. H. Thurston.

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